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DEVELOPMENT DOCUMENT FOR EFFLUENT LIMITATIONS GUIDELINES AND NEW SOURCE PERFORMANCE STANDARDS FOR THE FLAT GLASS SEGMENT OF THE GLASS MANFACTURING POINT SOURCE CATEGORY

Environmental Protection Agency

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Effluent limitations guidelines are set forth for the degree of effluent reduction attainable through the application of the "Best Practicable Control Technology Currently Available" and the "Best Available Technology Economically Achievable" which must be achieved by existing point sources by July 1, 1977 and July 1, 1983, respectively. The "Standards of Performance for New Sources" set forth a degree of effluent reduction which is achievable through the application of the best available demonstrated control technology processes, operating methods or other alternatives.

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for
EFFLUENT LIMITATIONS GUIDELINES
and
NEW SOURCE PERFORMANCE STANDARDS
for the
FLAT GLASS SEGMENT
# of the
GLASS MANUFACTURING POINT SOURCE CATEGORY

Russell E. Train
Administrator

Roger Strelow
Acting Assistant Administrator for Air & Water Programs

Allen Cywin
Director, Effluent Guidelines Division

Robert J. Carton
Project Officer

January 1974

Effluent Guidelines Division
Office of Air and Water Programs
U.S. Environmental Protection Agency
Washington, D.C. 20460

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ABSTRACT

This document presents the findings of an extensive study of the flat glass manufacturing industry by Sverdrup & Parcel and Associates, Inc. for the Environmental Protection Agency for the purpose of developing effluent limitations guidelines, Federal standards of performance, and pretreatment standards for the industry, to implement Sections 304, 306, and 307 of the "Act."

Effluent limitations guidelines contained herein set forth the degree of effluent reduction attainable through the application of the best practicable control technology currently available and the degree of effluent reduction attainable through the application of the best available technology economically achievable which must be achieved by existing point sources by July 1, 1977 and July 1, 1983, respectively. The Standards of Performance for new sources contained herein set forth the degree of effluent reduction which is achievable through the application of the best available demonstrated control technology, processes, operating methods, or other alternatives.

The development of data and recommendations in the document relate to the flat glass manufacturing and automotive glass fabricating segments of the glass manufacturing industry. These two segments are further subdivided into six subcategories on the basis of production processes and waste water characteristics. Separate effluent limitations were developed for each subcategory on the basis of the level of raw waste load as well as on the degree of treatment achievable by suggested model systems. These systems include, coagulation, sedimentation, filtration and certain in-plant modifications. Supportive data and rationale for development of the proposed effluent limitations guidelines and standards of performance are contained in this document.

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SECTION I

CONCLUSIONS

That part of the glass manufacturing industry covered in this document is classified into six subcategories. The first four subcategories refer to primary glass manufacturing. The last two subcategories deal with automobile window glass fabrication. The subcategorization is based on differences in production process and waste water characteristics. Factors such as raw materials, age and size of production facilities, and applicable treatment technology do not provide significant bases for differentiation. The subcategories indicated, are as follows:

1. Sheet Glass Manufacturing
2. Rolled Glass Manufacturing
3. Plate Glass Manufacturing
4. Float Glass Manufacturing
5. Automotive Glass Tempering
6. Automotive Glass Laminating

Recommended effluent limitations and waste control technologies to be achieved by July 1, 1977 and July 1, 1983, are summarized in Section II. It is estimated that the investment costs of achieving the 1977 limitations and standards by all plants in the industry is less than $900 thousand excluding costs of additional land acquisition. The costs of achieving the 1983 level is estimated to be an additional $2.3 million over the 1977 level.

SECTION II

RECOMMENDATIONS

The recommended effluent limitations for the pollutant constituents of major significance are summarized below for the six subcategories of the glass manufacturing point source category included in this document.

Using the Best Practicable Control Technology Currently Available the daily maximum limitations are as follows:

	Suspended Solids	Oil	Total Phosphorus
Sheet Glass	No waste water discharge		
Rolled Glass	No waste water discharge		
Plate Glass			
kg/metric ton	2.76		
(lb/ton)	(5.52)		
Float Glass			
g/metric ton	2.00	1.40	0.05
(lb/ton)	(0.0040)	(0.0028)	(0.0001)
Automotive Glass Tempering			
g/sq m	1.95	0.64	
(lb/ton)	(0.40)	(0.13)	
Automotive Glass Laminating			
g/sq m	4.40	1.76	1.07
(lb/ton)	(0.90)	(0.36)	(0.22)
pH	Between 6.0 and 9.0 (all subcategories		

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Using the Best Available Control Technology Economically Achievable, no discharge of process waste water pollutants to navigable water is recommended for the sheet and rolled glass subcategories. The daily maximum effluent limitations recommended for the other subcategories are as follows:

	Suspended Solids	Oil	Total Phosphorus
Plate Glass			
kg/metric ton	0.045	-	
(lb/ton)	(0.090)		
Float Glass			
g/metric ton	0.70	1.40	0.05
(lb/ton)	(0.0014)	(0.0028)	(0.0001)
Automotive Glass Tempering			
g/sq m	0.24	0.49	
(lb/ton)	(0.05)	(0.10)	
Automotive Glass Laminating			
g/sq m	0.88	1.76	0.30
(lb/ton)	(0.18)	(0.36)	(0.06)
pH	Between 6.0 and 9.0 (all subcategories)		

Recommended effluent limitations and standards of performance for new sources are no discharge for the sheet, rolled, and plate glass manufacturing subcategories and the Best Available Control Technology Economically Achievable for flat glass manufacturing, and automotive glass tempering and automotive glass laminating.

SECTION III

INTRODUCTION

PURPOSE AND AUTHORITY

Section 301(b) of the Act requires the achievement by not later than July 1, 1977, of effluent limitations for point sources, other than publicly owned treatment works, which are based on the application of the best practicable control technology currently available as defined by the Administrator pursuant to Section 304(b) of the Act. Section 301(b) also requires the achievement by not later than July 1, 1983, of effluent limitations for point sources, other than publicly owned treatment works, which are based on the application of the best available technology economically achievable which will result in reasonable further progress toward the national goal of eliminating the discharge of all pollutants, as determined in accordance with regulations issued by the Administrator pursuant to Section 304(b) of the Act. Section 306 of the Act requires the achievement by new sources of a Federal standard of performance providing for the control of the discharge of pollutants which reflects the greatest degree of effluent reduction which the Administrator determines to be achievable through the application of the best available demonstrated control technology, processes, operating methods, or other alternatives, including, where practicable, a standard permitting no discharge of pollutants.

Section 304(b) of the Act requires the Administrator to publish within one year of enactment of the Act, regulations providing guidelines for effluent limitations setting forth the degree of effluent reduction attainable through the application of the best practicable control technology currently available and the degree of effluent reduction attainable through the application of the best control measures and practices achievable including treatment techniques, process and procedure innovations, operating methods and other alternatives. The regulations proposed herein set forth effluent limitations guidelines pursuant to Section 304(b) of the Act for certain subcategories of the glass manufacturing point source category. They include sheet glass, rolled glass, plate glass, and float glass manufacturing, and automotive glass tempering and laminating.

Section 306 of the Act requires the Administrator, within one year after a category of sources is included in a list published pursuant to Section 306(b) (1) (A) of the Act, to propose regulations establishing Federal standards of performance for new sources within such categories. The Administrator published in the Federal Register of January 16, 1973 (38 F.R. 1624), a list of 27 source categories. Publication of the list constituted announcement of the Administrator's intention of establishing, under Section 306, standards of performance applicable to new sources within the flat glass industry subcategory as delineated above, which was included within the list published January 16, 1973.

SUMMARY OF METHODS USED FOR DEVELOPMENT OF THE EFFLUENT LIMITATIONS GUIDELINES AND STANDARDS OF PERFORMANCE

Purpose and Authority

The effluent limitations guidelines and standards of performance proposed herein were developed in the following manner. The point source category was first categorized for the purpose of determining whether separate limitations and standards are appropriate for different segments within a point source category. Such subcategorization was based upon raw material used, product produced, manufacturing process employed, and other factors. The raw waste characteristics for each subcategory were then identified. This included an analyses of (1) the source and volume of water used in the process employed, and the sources of waste and waste waters in the plant; and (2) the constituents (including thermal) of all waste waters; including toxic constituents and other constituents which result in taste, odor, and color in water, or aquatic organisms. The constituents of waste waters which should be subject to effluent limitations guidelines and standards of performance were identified.

The full range of control and treatment technologies existing within each subcategory was identified. This included an identification of each distinct control and treatment technology, including both inplant and end-of-process technologies, which are existent or capable of being designed for each subcategory. It also included an identification in terms of the amount of constituents (including thermal) and the chemical, physical, and biological characteristics of pollutants, of the effluent level resulting from the application of each of the treatment and control technologies. The problems, limitations and reliability of each treatment and control technology and the required implementation time was also identified. In addition, the non-water quality environmental impacts, such as the effects of the application of such technologies upon other pollution problems, including air, solid waste, noise and radiation were also identified. The energy requirements of each of the control and treatment technologies was identified as well as the cost of the application of such technologies.

The information, as outlined above, was then evaluated in order to determine what levels of technology constituted the "best practicable control technology currently available", "best available technology economically achievable", and the "best available demonstrated control technology, processes, operating methods, or other alternatives". In identifying such technologies, various factors were considered. These included the total cost of application of technology in relation to the effluent reduction benefits to be achieved from such application, the age of equipment and facilities involved, the process employed, the engineering aspects of the application of various types of control techniques, process changes, non-water quality environmental impacts (including energy requirements) and other factors.

Basis for Guideline Development

The data for identification and analyses were derived from a number of sources. These sources included EPA and industry-supplied information, published literature, and on-site visits, interviews, and sampling at typical or exemplary plants throughout the United States. References used in the guidelines for effluent limitations and standards of performance on new sources reported herein are included in Section XIII of this document.

Three types of waste water data were analyzed. These are RAPP data, industry supplied data, and data derived from the sampling of typical or exemplary plants. The data retrieval form illustrated in Figure 1 was developed to aid in the collection of data during interviews and plant visits and was supplied to the industry to indicate the types of data required for the study.

The data was analyzed with the aid of a computer program which provided the capability for summing the data for each plant where multiple discharges existed, averaging the data for each plant where multiple data sets were available, and comparing and averaging the data for all plants within each subcategory to determine values characteristic of a typical plant. Input to the computer for each plant consisted primarily of the plant production rate, the waste water flow rate, the concentration of each constituent plant intake water, the average and maximum concentrations of each constituent in the waste water, and some descriptive information regarding existing waste treatment methods, subcategory type, and sampling methods.

An example of the computer printout is the hypothetical summary of effluent suspended solids data for plate glass plants using lagoon treatment illustrated in Figure 2. The pound per day increase, mg/l increase and pounds added per day per production unit are calculated. Data from all of the plants listed is summarized in terms of the average, standard deviation (SIGMA) and minimum and maximum values for the data listed.

The name, location, and applicable manufacturing processes for the plants contacted in this study are listed in Table 1. Twenty-three plants supplied some type of usable information or data for computer analysis. RAPP data was available and used for 10 plants.

Ten plants covering various manufacturing combinations were visited. The subcategories covered are listed in Table 2 along with the type of data collected. Six of the plants were sampled, some with more than one subcategory. One plate, one float, 2 solid tempered automotive, and 3 laminating processes were sampled.

EPA FLAT GLASS STUDY

Data Retrieval Form No. 1

January, 1973

I GENERAL

- A. Company Name
- B. Plant Name and Location
- C. Contact - Company Personnel
  - Plant Personnel
- D. Telephone No.

II MANUFACTURING PROCESS CHARACTERIZATION (Separate sheet for each process)

- A. Process Type
- B. Production Rate
- C. Operating Schedule
- D. Number of Employees
- E. Water Requirements
  - 1. Volume and Sources
  - 2. Uses (including volume)
    - a. Cooling
    - b. Washing
    - c. Dust Suppression
    - d. Plant Cleanup
    - e. Sanitary (if available)
    - f. Other
    - g. Boiler Water
  - 3. Available Information on Raw Water Quality

-1-

EPA FLAT GLASS STUDY (Contd.)

- 4. Pretreatment Requirements
  - a. Volume Treated
  - b. Reason for Treatment
  - c. Describe Treatment System and Operation
  - d. Type and Quantity of Chemicals Used
  - e. Available Information on Treated Water Quality

II PROCESS WASTEWATER

- A. Volume and Sources
- B. Understanding of How and Why the Water is Used in the Process
- C. Does the Source Volume and Concentration of Wastewater Vary Depending on the Type or Quality of Glass Produced or Fabricated?
- D. Are Wastewater Characteristics Appreciably Different During Start-up and Shutdown as Compared to Normal Operation?
- E. Quantity and Point of Application of Oil, Detergent and Other Chemicals Used Which Might Enter the Wastewater Stream
- F. Available Information on Untreated Wastewater Quality
  - 1. BOD
  - 2. COD
  - 3. Total Solids
  - 4. Suspended Solids
  - 5. Dissolved Solids
  - 6. Oil and Grease
  - 7. Phosphorus
  - 8. MBAS

-2-

FIGURE 1

DATA RETRIEVAL FORM

EPA FLAT GLASS STUDY (Contd.)

9. Temperature
10. pH
11. Other (All available information should be collected)

G. Treatment Methods
  1. Wastewater Source and Volume
  2. Reason for Treatment
  3. Describe Treatment System and Operation
  4. Type and Quantity of Chemicals Used
  5. Available Information on Treated Wastewater Quality
    a. BOD
    b. COD
    c. Total Solids
    d. Suspended Solids
    e. Dissolved Solids
    f. Oil and Grease
    g. Phosphorus
    h. MBAS
    i. Temperature
    j. pH
    k. Other (All available information should be collected)
  6. Is Any Known Toxic Material in the Wastewater?

H. Wastewater Recycle
  1. Is Any Wastewater Recycled Presently?
  2. Can Wastewater be Recycled?

-3-

EPA FLAT GLASS STUDY (Contd.)

I. In Plant Methods of Water Conservation and/or Waste Reduction

J. Identify Any Air Pollution, Noise or Solid Wastes Resulting from Treatment or Other Control Methods. How is the Solid Waste Disposed of?

K. Cost Information (Related to water pollution control)
  1. Treatment Plant and/or Equipment Cost
  2. Operating Costs (Personnel, maintenance, etc.)
  3. Power Costs
  4. Estimated Equipment Life

L. Water Pollution Control Methods Being Considered for Future Application

III COOLING WATER

A. Process Steps Requiring Cooling Water

B. Heat Rejection Requirements (BTU/hour)

C. Type of System (Once through or recycle)

D. Water Temperatures and Flow Rate
  1. Input
  2. Output
  3. Flow Rate

E. Cooling Tower
  1. Direct or Indirect
  2. Blowdown Rate
  3. Blowdown Control Method
  4. Type and Quantity of Water Treatment Chemicals Used
  5. Available Information on Blowdown Water Quality

F. Type and Quantity of Chemicals Used for Once Through Cooling Water Treatment

IV BOILER

A. Capacity

B. Blowdown

-4-

FIGURE I (CONTD.)
DATA RETRIEVAL FORM

```
PART A AND B PARAMETERS OF INTAKE WATER AND DISCHARGE.  BREAKDOWN BY PLANT

       PLANT     INF.    EFF.    CONC.                                           LBS ADDED PER
                 CONC.   AVE.    MAX     LB/DAY INCREASE  MG/L INCREASE UNIT/DAY   PRODUCT UNIT
  MGD       GPM  MG/L    MG/L    MG/L    AVE        MAX   AVE  MAX             AVE      MAX      SAMPLE TYPE

ITEM NO.    530. TOTAL SUSPENDED SOLIDS

NAME= XYZ GLASS COMPANY              PRODUCTION= 100.   TONS/DAY,LAGOON,PLATE
 2.1     1458.33 11.     30.     375.    332.766 6375.09 19.     364.    100.    3.32766 63.7509COMP,MP227

NAME= ABC GLASS INDUSTRIES           PRODUCTION= 300.   TONS/DAY,LAGOON,PLATE
 5.96    4138.89 60.     75.     425.    745.596 18142.8 15.     365.    300.    2.48532 60.4761COMP,MP275


 8.06    5597.22 71.     105.    800.    1078.36 24517.9 34.     729.    400.    5.81298 124.227                  TOTAL
 4.03    2798.61 35.5    52.5    400.    539.181 12259.  17.     364.5   200.    2.90649 62.1135                  AVER.
 2.72943 1895.44 34.6482 31.8198 35.3553 291.915 8321.04 2.82843 0.7071  141.421 0.59562 2.31556                  SIGMA
 5.96    4138.89 60.     75.     425.    745.596 18142.8 19.     365.    300.    3.32766 63.7509                   MAX.
 2.1     1458.33 11.     30.     375.    332.766 6375.09 15.     364.    100.    2.48532 60.4761                   MIN.
```

FIGURE 2

SAMPLE COMPUTER FORMAT

TABLE 1

FLAT GLASS PLANTS

Company Name	Plant Location	Applicable Process
ASG	Greenland, Tenn.	P
	Kingsport, Tenn.	R
	Okmulgee, Okla.	S
	Jeanette, Pa.	S
Chrysler	Detroit, Mich.	L, T
CE	Fullerton, Calif.	R
	Erwin, Tenn.	R
	Floreffe, Pa.	R
	St. Louis, Mo.	R
Ford	Dearborn, Mich.	F, L, T
	Nashville, Tenn.	F, L, T
Fourco	Fort Smith, Ark.	S
Guardian	Millbury, Ohio	T
	Carleton, Mich.	F
	Detroit, Mich.	L
LOF	E. Toledo, Ohio	F, L, T
	Rossford, Ohio	F, P,* T
	Ottowa, Ill.	F, L, T
	Lathrop, Calif.	F, L, T
PPG	Creighton, Pa.	L
	Carlisle, Pa.	F
	Cumberland, Md.	F, P

* This operation has reportedly been closed

TABLE I (Contd.)

FLAT GLASS PLANTS

Company Name	Plant Location	Applicable Process
PPG	Meadville, Pa.	F
	Crystal City, Mo.	F
	Henryetta, Okla.	S
	Mt. Vernon, Ohio	S
	Clarksburg, W. Va.	S
	Mt. Zion, Ill.	S
	Fresno, Calif.	S
	Greensburg, Pa.	L
	Crestline, Ohio	T
	Tipton, Pa.	T
Safelite	Wichita, Kans.	L
	Enfield, N. C.	L
Safetee	Philadelphia, Pa.	L
Shatterproof	Detroit, Mich.	L

Note (1) F = Float Glass
P = Plate Glass (Including grinding and polishing)
R = Rolled Glass
S = Sheet Glass
L = Windshield Fabrication (laminating)
T = Solid Tempered Automotive Fabrication

TABLE 2

PLANTS VISITED

Plant Types	No. of Plants	Type of Data Obtained
Plate	1	(2)
Float	1	(1) (2)
Rolled	1	No Process Waste
Sheet	1	No Process Waste
Automotive Tempering	1	(1) (2)
Automotive Laminating	2	(1) (2)
Combined Float, Auto. Laminating and Auto. Tempering	2	(1) (2)
Combined Float, Plate and Auto. Tempering	1	(1) (2)

(1) - Individual process or subcategory

(2) - End-of-Pipe including all process and auxiliary wastes

GENERAL DESCRIPTION OF THE INDUSTRY

Production Classification

The U.S. Bureau of Census, Census of Manufacturers, classifies the flat glass manufacturing industry as Standard Industrial Classification (SIC) group code number 3211 under the more general category of Stone, Clay, Glass, and Concrete Products (Major Group 32). The four-digit classification code (3211) comprises industrial establishments primarily engaged in manufacturing flat glass and flat glass products from materials taken from the earth in the form of sand. This study also includes some plants which are engaged in the fabrication of glass products (automobile window glass) from purchased glass which is covered under SIC group code number 3231, Glass Products, Made of Purchased Glass.

Origin and History

Glass is thought to have been made in Persia 7000 years ago and is known to have been produced 2000 years ago in Egypt. It was first used for gems and was later made into hollow vessels such as jars and vases. A circular piece was used for a window in a bath house in Pompeii sometime between 600 B.C., when the city was founded, and 79 A.D., when it was destroyed by the eruption of Mt. Vesuvius. The glass was made by casting and then drawn with pincers. The glass blowpipe was invented at the beginning of the Christian era and led to two important methods for manufacturing flat glass; the crown process and the cylinder process. In the crown process (which was thought to have been invented by the Syrians), a sphere was blown, an iron rod was attached to the sphere opposite the blowpipe, and the blowpipe was cracked off. The iron rod was then used to spin the reheated sphere until it opened to a flat circular sheet. Glass-making was introduced in America by the English, and the first glass factory in America was erected by the beginning of the seventeenth century at Jamestown, Virginia.

During the nineteenth century, the crown process of making flat glass was replaced by the cylinder process in which a cylinder was blown, the ends were cracked off, the cylinder was split along the side, and then reheated so that it could be opened into a flat sheet. The cylinder process did away with the thick center and thick edge that were characteristic of the crown process. In addition, larger sheets could be formed. Various improvements were made in mechanizing the process, including using compressed air for blowing.

In 1904, a patent was granted to Emile Fourcault in Belgium for a process in which a flat sheet of glass could be drawn directly from a bath of molten glass. Two other methods were developed for making sheet glass at about the same time in America. These were the Colburn (or Libbey-Owens) process and the Pittsburgh process. All three processes are still in use and many improvements have been made since the original development. Although sheet glass has a high surface finish, the surfaces are inherently wavy and are unsuitable for mirrors or large windows in which undistorted vision is desired. This fault can be overcome by grinding and polishing the sheet glass, although ground and polished glass is produced today by the plate process and, to a lesser extent, by the rolled process.

The earliest plate glass was produced by a casting process invented in France in the middle of the seventeenth century. The glass was melted in pots, poured onto a casting table and then leveled to the required thickness with a roller. The glass was allowed to cool and was then ground with sand and water using finer grades of sand as the grinding progressed. The glass was then polished with feltcovered wheels fed with a fine abrasive slurry of iron oxide. These basic grinding and polishing steps are in use today, although continuous processes are now employed in manufacturing ground and polished plate glass. The latest method for producing high optical-quality glass is the float process, introduced by Pilkington Brothers Limited in 1959. The method gets its name from that part of the process in which the glass is drawn across a bath of molten tin. Heat is applied and, together with the effect of gravity, a distortion-free sheet of glass is produced which has the high surface-quality of sheet glass. Float glass is rapidly replacing ground and polished plate glass.

Description of Manufacturing Methods

Manufacture of the basic sheet of flat glass from sand and other raw materials is defined as primary flat glass manufacturing. Sheet, rolled, plate, and float glass are primary flat glass products. The primary glass sheets may be used directly or may be fabricated into glass products as indicated in Figure 3. Among the many fabricated products are mirrors and other coated glass, automotive and architectural tempered glass, windshields, and numerous speciality products such as bulletproof glass, basketball backboards, and glass hot plates. Tempered automobile glass and windshields are the only fabricated products covered by this study.

Primary Flat Glass Manufacturing-

Flat glass is manufactured by melting sand together with other inorganic materials and then forming the molten material to a flat sheet. Within the primary flat glass industry, several distinct methods are used to make flat glass. These are the float, plate, sheet, and rolled processes. Although the raw materials and the melting operations are essentially the same, each process uses a different method for forming the molten glass into a flat sheet. In the float process, the glass is drawn across a molten tin bath while in the plate process, rolls control the initial thickness with the final thickness determined by grinding and polishing. The glass is formed by a vertical

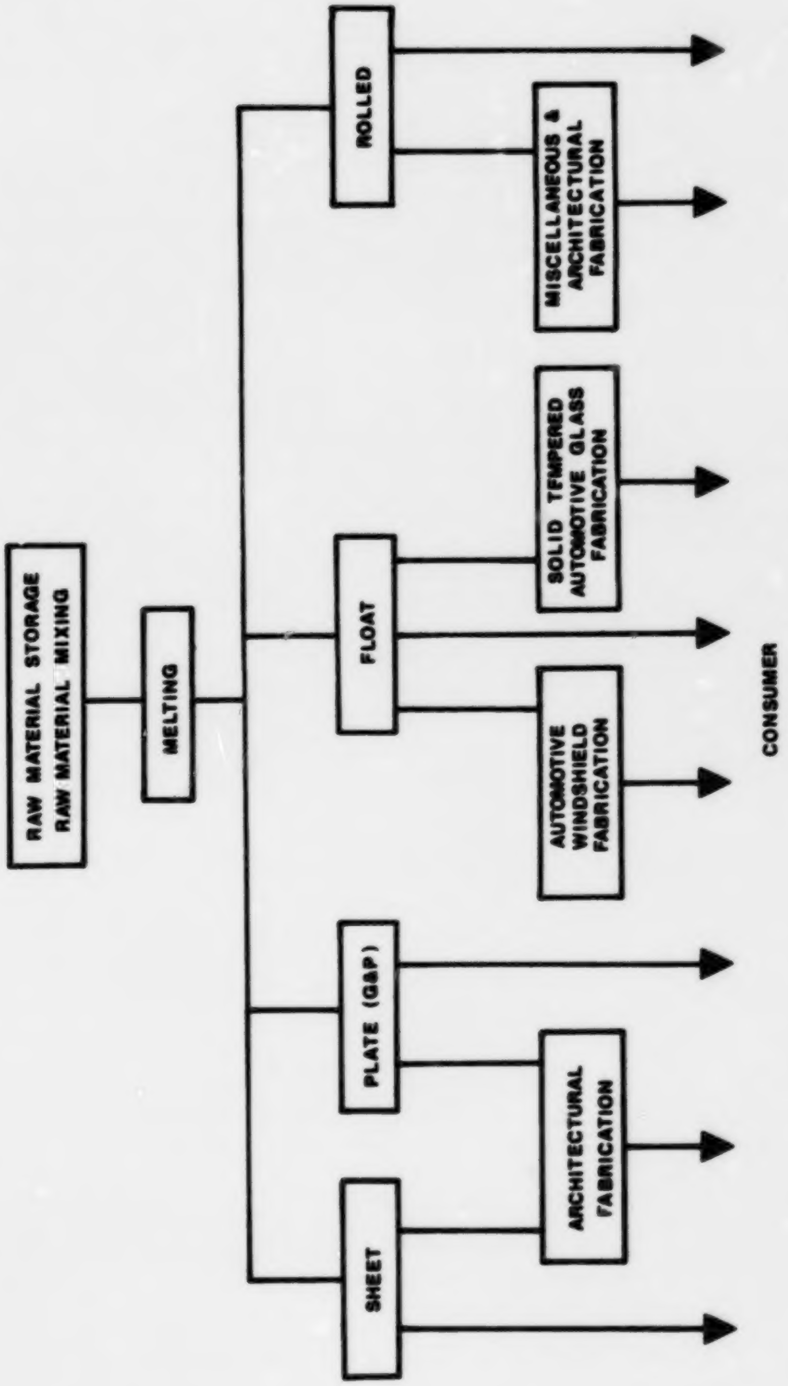

RAW MATERIAL STORAGE
RAW MATERIAL MIXING
MELTING
SHEET
PLATE (G&P)
FLOAT
ROLLED
ARCHITECTURAL FABRICATION
AUTOMOTIVE WINDSHIELD FABRICATION
SOLID TEMPERED AUTOMOTIVE GLASS FABRICATION
MISCELLANEOUS & ARCHITECTURAL FABRICATION
CONSUMER

FIGURE 3
FLAT GLASS INDUSTRY

drawing process in the sheet process. Finally, texturizing rolls are used to impart various surface textures in the rolled process.

All primary glass may be used as architectural glass. Plate glass is used in preference to sheet where a distortion-free glass is desired. Rolled glass is used where a decorative or translucent surface is desired. Float glass is used for the same purposes as plate glass, both of which can serve as the raw material for automobile window glass. Fabricated glass is produced using all of the primary glass types.

Automobile Window Glass Fabrication-

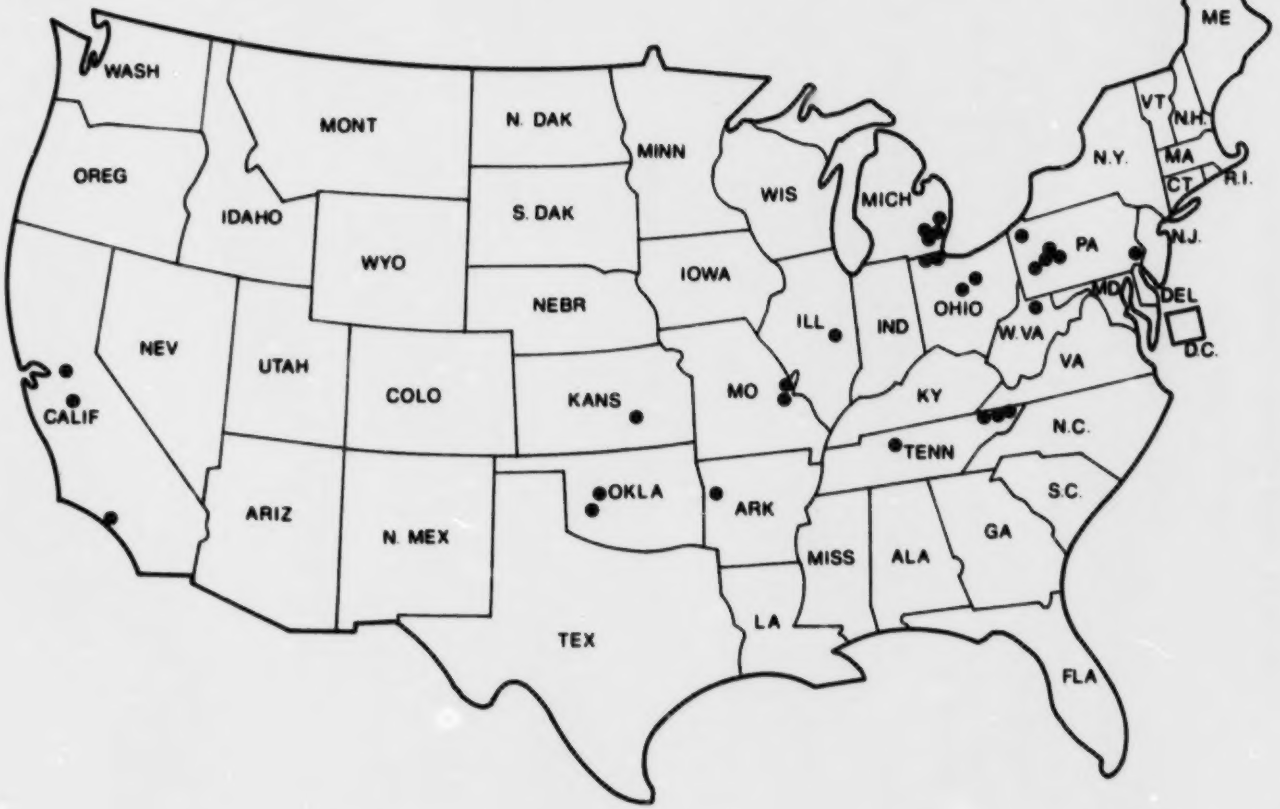
Automobile window glass fabrication is divided into two processes. Windshield laminating consists of bonding two layers of glass to an inner layer of vinyl plastic. The major unit of equipment in the process is the autoclave which is used to complete the bonding operation under conditions of high temperature and pressure. The purpose of laminating is to make the glass shatter resistant. Unlike windshields, side and back lights (windows) are fabricated from solid pieces of glass. The process includes edge grinding, bending and tempering. The purpose of tempering (heating, followed by rapid cooling) is to increase the strength of the glass over that of ordinary annealed glass and to cause it to shatter into small rounded pieces, should it be broken.

PRODUCTION AND PLANT LOCATION

There are a total of 36 plants owned by 11 companies which manufacture flat glass and fabricate automobile window glass in the United States (See Figure 4 and Tables 3 and 4), with a combined daily processing capacity of 10,700 metric tons (11,800 short tons) of primary flat glass products and 173,000 square meters (1.86 million square feet) of automotive glass products. The daily capacity of an average plant engaged in primary flat glass manufacturing is 413 metric tons (455 short tons). These plants range in size from 54 metric tons (60 short tons) per day to 1090 metric tons (1200 short tons) per day. (Note: During the course of this study one plate process was reported to have closed. The following data, however, include this operation.)

The daily capacity of an average plant engaged in automotive glass fabrication is 10,800 square meters. These plants range in size from 2,000 square meters (22,000 square feet) per day to 24,700 square meters (266,000 square feet) per day.

Total employment in the industry is 24,000 with an average of 670 employees per plant. Plant employment ranges from about 100 to 2900. It should be noted that employment figures are based on plant totals. Many of the plants carry on production processes (such as architectural glass fabricating) which are not covered by the study.


WASH
OREG
CALIF
IDAHO
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MONT
WYO
UTAH
ARIZ
COLO
N. MEX
N. DAK
S. DAK
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ALA
OHIO
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VA
N.C.
S.C.
N.Y.
MD
DEL
D.C.
N.J.
VT
N.H.
MA
CT
R.I.
ME

FIGURE 4

LOCATION OF FLAT GLASS MANUFACTURING PLANTS WITHIN THE UNITED STATES, 1973

PRIMARY FLAT GLASS MANUFACTURING

PRODUCTION DATA

	Float	Plate	Sheet	Rolled
Number of Plants	11	3	8	5
Total Capacity (metric tons/day)	6430	970	2720	670
Average Plant Size (metric tons/day)	580	330	340	140
Range (metric ton/day)	330-1090	250-390	150-600	55-230
Total Capacity (short tons/day)	7080	1070	3000	740
Average Plant Size (short tons/day)	640	360	370	150
Range (short tons/day)	360-1200	270-425	170-660	60-250
Plants Discharging to Municipal Treatment Systems	20%	0%	No Process Waste	No Process Waste

TABLE 4

AUTOMOTIVE GLASS FABRICATING

PRODUCTION DATA

	Laminating	Tempering
Number of Plants	11	9
Total Capacity (sq m/day)	75,200	97,500
Average Plant Size (sq m/day)	6,900	10,900
Range (sq m/day)	65-15,800	1,390-24,700
Total Capacity (sq ft/day)	810,000	1,050,000
Average Plant Size (sq ft/day)	74,000	117,000
Range (sq ft/day)	7,000-170,000	15,000-266,000
Plants Discharging to Municipal Treatment Systems	30%	20%

GENERAL PROCESS DESCRIPTION

Primary Flat Glass Manufacturing

Primary flat glass manufacturing consists of batching, melting, forming, annealing, and cutting. Grinding, polishing, and washing are included in the plate process, and washing is included in the float process. All of the processes use water for cooling. The basic unit of production for primary flat glass manufacturing is the metric ton (or short ton in English units) and is based on the amount of glass drawn from the melting tank.

These units were chosen because this is the most common measure of production for primary glass manufacturing and the data will be readily available for enforcement personnel. In some cases, production is measured in terms of tons of raw material fed to the furnace, but this is easily converted by subtracting the weight volatilized during the melting process. A weight loss of 18% was assumed for this study.

Raw Materials-

The most common type of flat glass produced is the soda-lime type which is also used for bottles, light bulbs, and eye glasses. The basic composition remains the same, although there may be minor differences in raw material composition depending on the manufacturer and the process (float, plate, sheet or rolled). The principal ingredient is sand (silica), which accounts for about half of the batch. Other major ingredients are soda ash (sodium carbonate), limestone (calcium carbonate), dolomite (magnesium carbonate), and cullet. Soda ash is added to reduce the viscosity of the melt and thus lower melting temperatures. Limestone and dolomite are added to improve the chemical durability of glass. Carbon dioxide is evolved from the soda ash, limestone, and dolomite during the melting process, leaving sodium oxide, calcium oxide, and magnesium oxide in solution with the silica (silicon dioxide). The amount of evolution of carbon dioxide is about 18% by weight of the total charge less cullet.

Cullet is waste glass that is inevitably produced in the glass manufacturing process, both inadvertently and intentionally, and may be 25% of the total amount of glass removed from the melting tank. The cullet is reprocessed with the raw materials and actually improves the melting qualities of the batch because of its tendency to melt faster than the other ingredients, thus providing starting points from which the melting can proceed. Other ingredients are often added to accomplish specific purposes. For example, iron oxide is added in small amounts to produce the blue-green color in tinted automotive glass.

Batching-

In the batching operation, the raw materials are brought together and mixed to a homogeneous consistency. Good mixing is very important in maintaining uniform physical properties in the finished product. Likewise, impurities in the raw materials must be kept to a minimum to avoid imperfections which result in rejection of the finished product.

Melting-

In the melting operation, the raw materials are continuously fed into the refractory-lined melting tank where they are heated using fuel oil or natural gas. Because of the high temperatures involved, all melting tanks use large amounts of cooling water to maintain structural integrity.

Forming-

Up to this point, the operations are essentially the same regardless of process. As the molten glass progresses through the melting tank, it is allowed to cool somewhat to facilitate removal from the tank in a continuous ribbon. It is the manner in which the ribbon is removed from the tank and the subsequent means used to effect dimensional control and surface texture that distinguishes between the sheet, plate, rolled, and float glass processes.

The glass is vertically drawn from the melting tank in the sheet glass process. The drawing process is started by lowering a bar into the molten glass and then pulling it out. The glass adheres to the bar and forms a continuous ribbon as the bar is raised. The glass cools and hardens as it is raised, after which powered rollers are applied to the ribbon to maintain a continuous drawing operation. The thickness of the glass is approximately inversely proportional to the drawing speed.

In the plate process, the molten glass flows by gravity to a pair of water-cooled forming rolls which determine the thickness of the glass. The rolled-glass operation is similar except that the rolls may be texturized to impart a decorative and diffusing surface. Wired glass is another product of the rolled glass operation. Two pairs of forming rolls are used to produce two ribbons of glass. A wire mesh is inserted between the two ribbons which are then brought together while the glass is still hot and soft so that bonding occurs.

In the float process, the glass is passed out of the melting tank onto a molten-tin surface. Heat and the force of gravity combine to provide a product with optical qualities similar to that of ground and polished plate glass. The advantage of the float process over the plate process is that grinding and polishing are not required.

Annealing-

Each of the primary manufacturing processes incorporates an annealing lehr in which internal stresses are removed by heating the glass to a uniform temperature followed by controlled cooling. Following annealing, the glass is cut.

Grinding and Polishing-

Plate glass must be ground and polished to achieve the flat and parallel surfaces that are required for good optical quality. Large rotary grinding machines are used. The cast iron grinding tools are called laps, and use a grinding medium which is a slurry of sand and water. Coarse sand is used in the initial stages of grinding, but progressively finer sand is used as the glass passes through successive grinding stages. The grinding slurry is recycled through classifying equipment which continuously grades the sand and feeds each section of the grinding machine with a slurry of water and appropriately sized sand. Sand and glass grindings that are too fine to use for grinding are discharged in a continuous blowdown. It should be pointed out that the classifying operation is sensitive to contamination. Contaminants may cause an upset resulting in a shutdown of grinding operations. A matter of days may be required to restore proper operation.

Polishing is accomplished with rotary equipment using animal felt as the polishing surface and a slurry of water and iron oxide or cerium oxide as the polishing medium. Grinding equipment and some polishing equipment in use today is of the "twin" configuration in which both sides of the glass are ground and polished concurrently. With "single" polishing equipment, glass is conveyed through the polishing operation on tables that have been coated with gypsum or some other supporting medium to prevent movement of the glass. During grinding and polishing, the glass thickness is reduced by approximately 15 percent.

Washing-

Washing is always performed in the plate process to remove residual grinding slurry and polishing rouge. In some cases, float glass is washed to remove sodium sulfate which forms on the glass as a result of a chemical reaction with sulfur dioxide. The sulfur dioxide is sprayed to prevent roller marks as the glass passes through the annealing lehr. No washing is done as a part of the sheet and rolled glass primary manufacturing processes. Sheet and rolled glass manufacturers may also do some fabricating (usually architectural) in addition to their primary manufacturing operations. In most cases, glass washing is required. The washing is a fabricating step and, as such, is not a part of primary manufacturing operations.

Cooling-

Large amounts of heat energy are used in the manufacturing of flat glass and lead to large usages of cooling water to protect the equipment from excessive temperatures. Cooling water is required for all melting tanks, for the float bath in the float glass process, the forming rolls in the plate glass and rolled glass processes, and for the drawing kiln in the sheet glass process. In addition, cooling water is required for the plant compressors and may also be used for the annealing lehr.

Heat energy that is dissipated by cooling water is called heat rejection in this report. Heat rejection is defined as the heat energy leaving the process in the discharge water minus the heat energy entering the process in the intake water.

For primary manufacturing plants, most of the process waste heat is dissipated directly to the atmosphere. Based on information from one source, the total heat energy required for manufacture of flat glass is about 3,000,000 kilogram-calories per metric ton (11,000,000 Btu/short ton) of glass removed from the melting tank. Average heat rejection by means of cooling water systems is about 600,000 kg-cal/ metric ton (2,200,000 Btu/short ton). Based on the large amounts of cooling water required, some plants have found it advantageous to be located near rivers while others use cooling towers or spray ponds to dissipate waste heat.

It should be pointed out that the heat rejection values presented later in this report are only estimates. Heat rejection is difficult to define because of varying flow rates and varying temperatures which can be caused by changes in intake temperature and in process operating conditions. For example, cooling water requirements for melting tank operations can vary over the life of the melting tank from one rebricking to the next. Melting tanks require rebricking approximately every four years. Over the course of the four years, the melting tank brick work will degrade and molten glass leaks can occur in the walls. A leak is repaired by locating an auxiliary cooler at the hole to freeze the molten glass and, thus, plug the hole. The addition of the cooler results in increased use of cooling water and, consequently, a higher heat rejection rate.

Heat rejection was computed in two different ways. For a once-through cooling system, it was necessary to determine the average intake and average discharge water temperatures and the average flow rate. Unless continuous monitoring was employed, the values had to be estimated. Heat rejection for a recycling cooling system could be determined if the cooling tower or spray pond make-up water flow rate was known. Make-up requirements are an indication of the evaporation rate which is proportional to the heat rejection rate.

Automobile Window Glass Fabrication

Automobile window glass fabrication includes windshield laminating and side and back light (side and back window) solid tempering. The basic unit of production for automotive fabrication is expressed in square meters (or 1000 sq ft in English units) of the surface area (one side) of finished glass.

These units were chosen because they are used at all of the plants studied to measure automobile glass production. Waste water volume and characteristics are related to the square meters (square feet) of glass fabricated.

Windshield Laminating-

Windshield laminating consists of bonding two layers of glass, which have been cut and bent to the proper size and curvature, to an inner layer of vinyl plastic. Bending is accomplished in a bending lehr. Heat is applied to the glass and a form is provided to assure the proper curvature. Mating panes are bent together to assure that both are of the same curvature. A parting material is applied to the panes before bending to prevent sticking.

Bonding of the two layers of glass to the vinyl plastic is done in two steps, sometimes referred to as prepressing and pressing. Prepressing is generally done with rollers. The large manufacturers do their final pressing in an oil autoclave in which oil is the medium for transmitting pressure and temperature changes to the windshield to induce bonding. Oil autoclaves are typical for the industry.

Vinyl plastic sheet is purchased in rolls. Before assembling the plastic into rolls, the manufacturer applies a coating of sodium bicarbonate to prevent sticking of adjacent layers during shipment and storage.

Cutting the glass leaves a sharp edge so that most manufacturers find it desirable to seam (sand or rough grind) the edges for safety in handling. Some manufacturers seam immediately after cutting while others wait until after pressing.

Several washing operations are required. The glass is washed before bending to remove contaminants that could be baked on the glass due to the high temperatures in the bending lehr; before prelamination assembly to assure cleanliness of the inner surfaces; and after pressing to remove the oil which adheres to the glass. The prelamination wash has been eliminated at some plants. Washing is also required to remove bicarbonate of soda from the vinyl plastic prior to prelamination assembly. If seaming occurs after autoclaving, the glass is again washed before shipment to the customer.

Large amounts of heat are required in the autoclave operation to produce the temperatures necessary for bonding. Following lamination, non-contact cooling water is used to cool the glass.

A few small manufacturers, producing windshields for the replacement windshield and recreational and farm vehicle markets, are using air autoclaves. In the air autoclave, air is the medium for transmitting the required pressure and temperature changes to the windshield. The advantage of the air autoclave is that it is not necessary to wash the glass after autoclaving; however, increased handling may be required with an air system. The trend in the industry is towards air autoclaving. Some of the large manufacturers have indicated that any new laminating facilities will be equipped with air autoclaves.

Automotive Solid Tempering-

Production of automotive side and back lights consists of cutting, edge grinding, seaming, drilling, bending, and tempering. The edges of side lights that will be exposed after being assembled into the automobile (the edges that are exposed when the window is rolled down) are ground to a smooth radius for appearance and safety. The other edges may be seamed to facilitate safe handling during subsequent fabricating steps. Hole drilling is performed on some lights to provide for special fabricating requirements of the automobile manufacturer. Bending is accomplished in a bending lehr by heating the glass to achieve the proper curvature, and the glass is tempered by rapid cooling after heating. Either air or water quenching may be used. Tempered glass is stronger than ordinary annealed glass and it breaks into tiny rounded pieces that will not cut a person's skin. Cooling water is required in the tempering hearth.

Edge grinding requires the use of a cooling solution which is recirculated through settling tanks to remove the glass solids. These solids are disposed of as landfill. Washing is required before bending to remove residue from the edge grinding and drilling operations.

SECTION IV

INDUSTRY CATEGORIZATION

The segments of the flat glass industry covered by this study are primary flat glass manufacturing and automotive glass fabrication. A general distinction can be made between primary manufacturing and automotive fabrication based on differences in raw materials used, products produced, and production methods employed. These factors were discussed in detail in the preceding paragraphs. The expression of primary production in terms of weight and fabricated production in terms of area is an indication of the basic difference.

The following factors were considered with respect to further subcategorization within the above two general categories:

Raw materials

Age and size of production facilities

Products and production processes

Waste water characteristics

Treatment methods

It is concluded that primary flat glass manufacturing should be subcategorized as sheet, rolled, plate, and float glass manufacturing and that automobile window glass fabricating should be subcategorized as automotive glass tempering and automotive glass laminating. Products and production methods are the primary bases for subcategorization.

Raw Materials

The raw materials for primary flat glass manufacturing do not provide a basis for subcategorization since they are essentially the same regardless of the process and in themselves have no direct effect on waste water quality. The same reasoning applies to automotive fabricating in which the raw material is flat glass, generally from the float process.

Age and Size of Production Facilities

Age is not a factor for the float process because it has only been used since 1959. There are only three plate lines in the country. These are the most modern as the older, less-efficient facilities have already been phased out. Sheet and rolled glass plants are of varying age but since no process water is used, age is not a significant factor except that the cooling water requirements are probably greater for older melting tanks. Laminating and tempering facilities are continuously being

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modernized so that plant age is not a factor in automotive fabrication.

Waste water volumes and flow rates expressed in terms of production do not vary significantly with respect to plant size. Basic process equipment is generally the same for each subcategory throughout the industry. The larger the plant, the more parallel equipment employed. For these reasons, plant age and size are not a basis for subcategorization.

Products and Production Processes

Readily identifiable production methods characterize the manufacturing processes by which the various primary and fabricated products are made. The float process is characterized by the molten tin bath; the plate process by grinding and polishing; the rolled process by the texturizing rolls; the sheet process by vertical drawing; the laminating process by the oil autoclave; and the tempering process by edge grinding, hole drilling, and tempering. Each of these processes has different requirements for water, resulting in different waste water characteristics and treatment requirements. Heat rejection requirements also differ for the different manufacturing processes. The variation in production methods forms a significant basis for subcategorization. Many flat glass plants have more than one manufacturing process contributing to the total waste stream. A typical multi-product plant may have a float line as well as automotive laminating and tempering facilities. This phenomenon is additional justification for subcategorization by process. Performance standards will be recommended on a subcategory by subcategory basis. In this way, the total effluent limitation for a multi-product plant can be determined by summation.

Waste Water Characteristics

Waste water volume and characteristics vary widely for the different manufacturing processes. No process waste water is produced by rolled and sheet glass manufacturing. A small volume of clean water results from washing in the float process. Grinding and polishing in the plate process produces large volumes of high suspended solids waste water. Windshield fabrication produces a lower volume of oily waste water and solid tempered automotive glass production results in a still lower volume of somewhat cleaner waste water. The variation in waste volume and characteristics is a basis for subcategorization.

Treatment Methods

Although waste water volume and characteristics vary significantly, applicable treatment methods are all related to the removal of oil, and suspended and dissolved solids. Some of the same treatment methods apply to more than one subcategory and, therefore, variation in treatment methods is only partial basis for subcategorization.

SECTION V

WATER USE AND WASTE CHARACTERIZATION

Water is used to some extent in all of the subcategories covered by this study. Cooling and boiler water are required at all plants. Washwater is used in the plate, float, and automotive fabrication subcategories for washing, and water is the transfer medium for grinding sand and rouge in the plate process.

Plant water is obtained from various sources including the city water supply, surface, or ground water. City water is used in almost all cases where it is available, except for plate glass manufacturing where large quantities of river water are used for grinding and polishing.

AUXILIARY WASTES

For the purposes of this study, non-contact cooling, boiler, and water treatment waste waters are considered auxiliary wastes as distinguished from process waste waters. Process waste water is defined as water which has come into direct contact with the glass, and include such sources as washing, quenching, and grinding and polishing.

Pretreatment requirements depend on the raw water quality and the intended water use. Cooling water pretreatment practices may range from no treatment to coagulation-sedimentation, filtration, softening, or deionization. Generally, treatment is sufficient to prevent fouling of the cooling system by clogging, corrosion, or scaling. Boiler water treatment is related to boiler requirements, but removing the suspended solids and at least a portion of the dissolved solids are generally required. Filtration, softening, aeration, and deionization are done as necessary. Washwater must be low in suspended and dissolved solids to avoid spotting the glass. City water is used, where available, or water from other sources is treated to obtain water of similar quality. In some cases deionized water is required for final rinsing.

Waste waters from pretreatment systems are highly variable and depend upon the characteristics of the water being treated. At two plants in the same subcategory, therefore, no pretreatment may be required at one while coagulation-sedimentation, filtration, and deionization may be required at the other. For plants with the same system, the pretreatment waste volume and characteristics are also proportional to the concentration of pollutants removed.

Cooling and boiler systems, associated water treatment requirements and waste water characteristics vary considerably among the plants in the flat glass industry. Existing cooling systems include once-through and direct-contact and indirect-contact recir-

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culating systems. Highly variable cooling water treatments are used in these systems. Boiler systems may also vary considerably in terms of chemical treatment and blowdown. The volume and characteristics of cooling and boiler waste waters are directly related to the make-up water characteristics and the type of system employed.

Auxiliary waste waters are not unique to the flat glass industry. Many manufacturing operations throughout industry use the same cooling, boiler, and water pretreatment systems. Owing to their highly variably volume and characteristics, auxiliary waste waters are not included in the effluent limitations and standards of performance developed for process waste waters. Auxiliary waste waters will be studied at a later date, and characterized separately for industry in general. The values thus obtained will be added to the limits for process waste water to determine the effluent limitations and standards of performance for the total plant.

In this report, cooling requirements will be discussed in terms of heat-rejection requirements. Where appropriate, some of the types of systems used may be discussed; however, no attempt will be made to define or categorize the equipment and systems used, the cooling-water treatment methods, or the effluent characteristics. Water pretreatment methods will be discussed where applicable to process water treatment and washes that may require deionized water will be noted.

SHEET GLASS MANUFACTURING

Sheet glass manufacturing operations may be defined as the processing of raw materials to form thin glass sheets of saleable size. Figure 5 is a flow diagram indicating water usage with respect to the manufacturing steps. The manufacturing process has been defined in detail in Section IV. Non-contact cooling water is used, but no process waste water is produced by this subcategory.

Process Water and Waste Water

The only water used in the process is 42 l/metric ton (10 gal/short ton) added to the raw materials for dust suppression. This is evaporated in the melting tank.

No process water is used and, therefore, no process waste water is produced by the sheet-glass subcategory. However, it should be noted that architectural tempering or other waste water-producing fabrication steps may be operated in the same facility in which sheet glass is produced. The effects of fabrication steps must be considered when analyzing the total effluent from a sheet glass facility.

Cooling

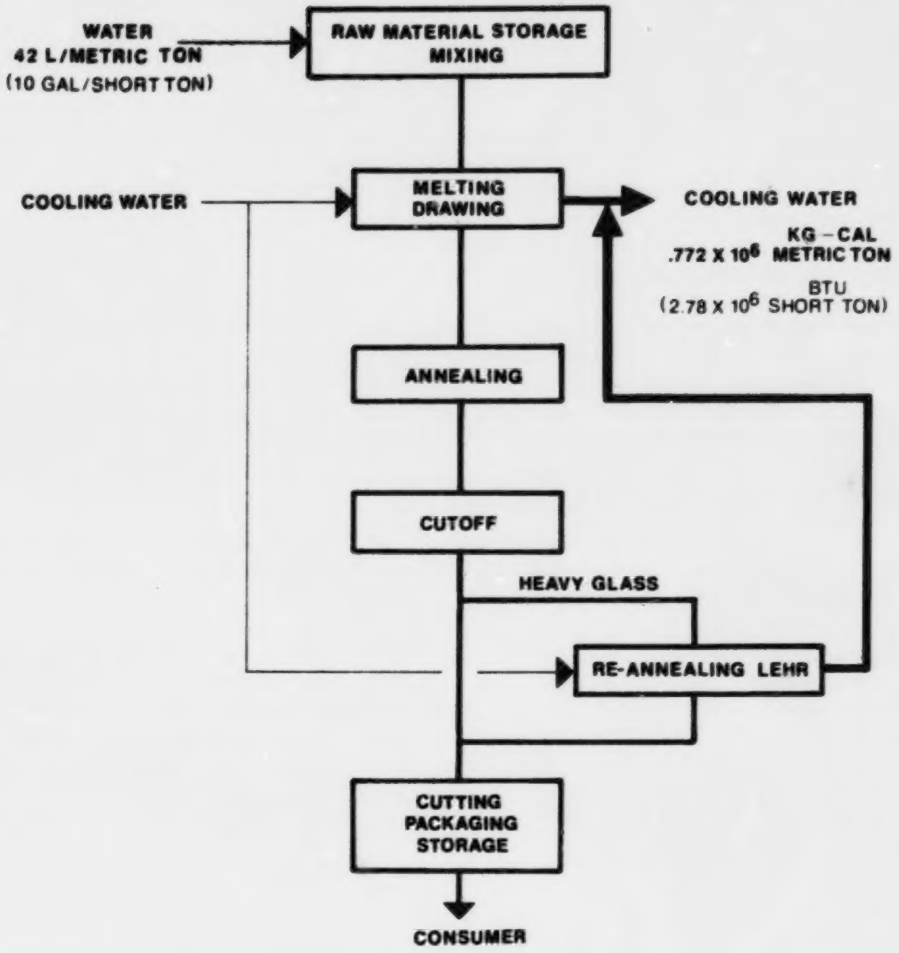
WATER
42 L/METRIC TON
(10 GAL/SHORT TON)
RAW MATERIAL STORAGE
MIXING
COOLING WATER
MELTING
DRAWING
COOLING WATER
.772 X 10^6 KG-CAL/METRIC TON
(2.78 X 10^6 BTU/SHORT TON)
ANNEALING
CUTOFF
HEAVY GLASS
RE-ANNEALING LEHR
CUTTING
PACKAGING
STORAGE
CONSUMER

FIGURE 5

SHEET GLASS MANUFACTURING

In the sheet glass manufacturing process, cooling water is required for the melting tank, drawing kiln, compressors and the reannealing lehr. Average heat rejection for plants using the Pennvernon process is 772,000 kilogram-calories per metric ton (2,780,000 Btu/short ton) with a range of 741,000 kg-cal/metric ton (2,670,000 Btu/short ton) to 877,000 kg-cal/metric ton (3,160,000 Btu/short ton). Another sheet glass plant, using the Fourcault process, reports heat rejection at 350,000 kg-cal/metric ton (1,260,000 Btu/short ton). The reason for the difference in heat rejection between the Pennvernon process and the Fourcault process is the relative proximities of the drawing kiln to the melting tank. In the Fourcault process the molten glass flows in a canal to the drawing kiln which is not as close to the melting tank as in the Pennvernon process. By traveling the longer distance (by way of canals), the glass has an opportunity to cool so that not as much cooling water is required in the drawing kiln. The Libbey-Owens process is also used for making sheet glass. No heat-rejection data was available from these plants.

ROLLED GLASS MANUFACTURING

Rolled glass manufacturing consists of melting raw materials and drawing the molten glass through rollers to form a glass sheet. The major process steps and points of water usage are listed in Figure 6. Non-contact cooling water is used, but no process waste water is produced by this subcategory.

Process Water and Waste Water

Approximately 42 l/metric ton (10 gal/short ton) of water are added to the raw materials for dust suppression. This water is evaporated in the melting tank.

No process water is used and, therefore, no process waste water is produced by the rolled glass subcategory. Fabricating operations generally occur in conjunction with rolled glass manufacturing and should be noted that numerous and highly variable waste water streams may result. Although primary rolled-glass production is a dry process, waste waters may be generated by a rolled glass facility because of fabrication waste water.

Cooling

In the rolled-glass manufacturing process, cooling water is required for the melting tank, forming rolls, annealing lehr and compressors. Although no heat-rejection data is available for rolled glass plants, it is expected that heat rejection requirements are similar to the plate glass process because of similarities in process configuration.

PLATE GLASS MANUFACTURING

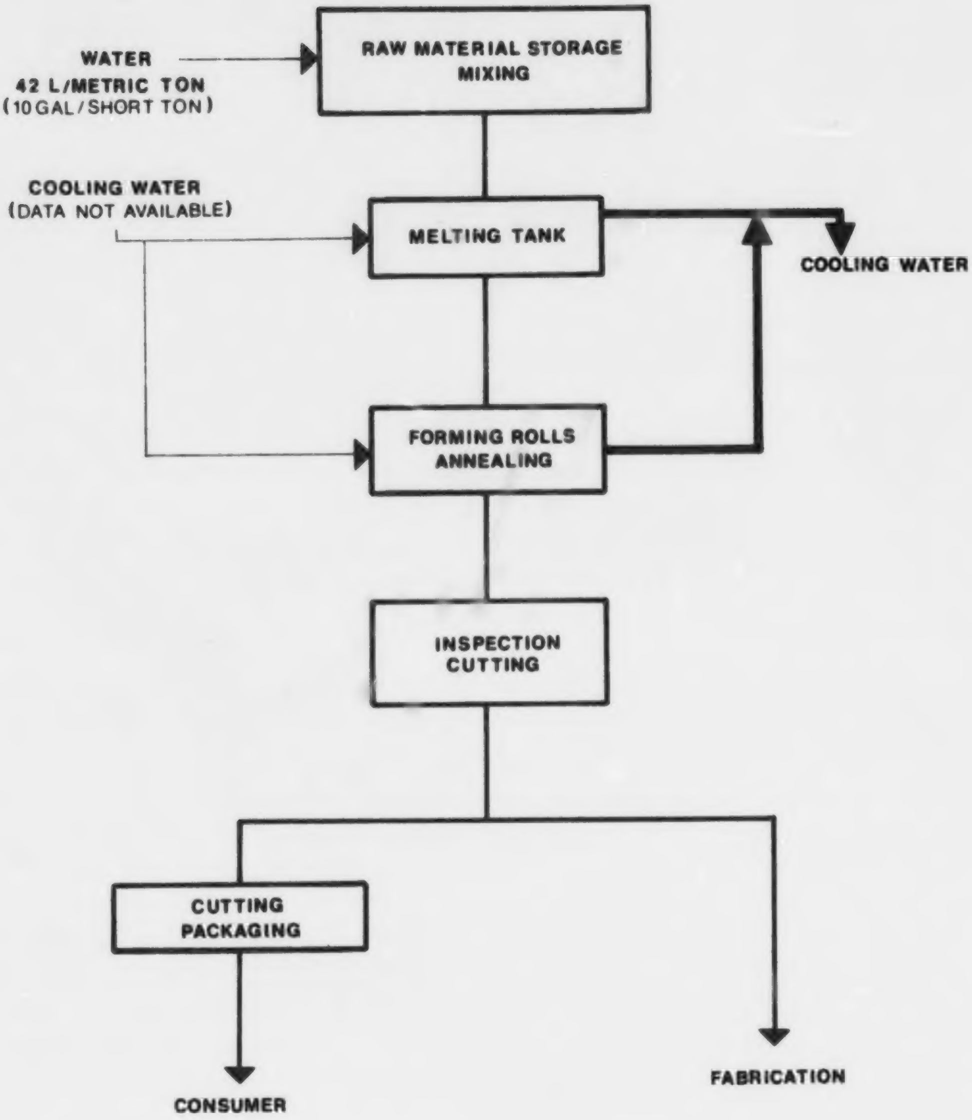
RAW MATERIAL STORAGE
MIXING
WATER
42 L/METRIC TON
(10 GAL/SHORT TON)
COOLING WATER
(DATA NOT AVAILABLE)
MELTING TANK
COOLING WATER
FORMING ROLLS
ANNEALING
INSPECTION
CUTTING
CUTTING
PACKAGING
CONSUMER
FABRICATION

FIGURE 6

ROLLED GLASS MANUFACTURING

Plate glass manufacturing is the production from raw materials of a high-quality thick glass sheet. This subcategory has historically been the greatest source of waste in the industry since large volumes of high suspended-solids waste water are produced. Owing to high production costs and related water pollution problems, plate glass is being replaced by float glass. Only three plate glass plants remain in the United States. The major process steps and points of water usage are shown in Figure 7.

The typical plate glass manufacturing plant may be located in any part of the country and is at least 12 years old. Advanced plate glass manufacturing technology is used, but this has not been improved since the early 1960's when the advantages of the float process became apparent. Production is continuous seven days a week.

Process Water and Waste Water

Process water is used in the batch, grinding, polishing, and washing operations. Approximately 42 l/metric ton (10/short ton) of water are added to the raw materials for dust suppression. This water is evaporated in the melting tank. Waste water results from grinding, polishing, and washing the glass. River water is generally used for grinding and polishing, but city or treated water is required for final washing and rinsing.

Grinding-

Grinding is the first step in the process to transform the rough glass sheet into the finished plate-glass product. A sand slurry is used in conjunction with large iron grinding wheels to actually grind down the glass surface. Relatively coarse sand is used initially, with progressively finer sand used as the glass proceeds down the grinding line. Sand slurry is recycled from a gravity classifier. All of the return from the grinders enters one end of the classifier, the sand particles settle according to size, and the waste water overflows at the other end. The grinding slurry is drawn from progressive segments of the bottom of the tank. Sand classification is regulated by the velocity of water passing through the tank and is controlled by both the slurry drawoff rate and the tank overflow. Particles too small to settle are removed in the overflow. This waste water stream is very high in suspended solids consisting of fine sand, glass, and iron particles. About 87% of the flat glass waste water is contributed by the grinding process.

Polishing-

Polishing is similar to grinding except that smaller particles are used. Rouge (ferric oxide) has generally been used as the polishing medium, but at least one company uses cerium oxide. Neither grinding medium has an apparent advantage in terms of raw waste water characteristics. Felt pads are used to apply the

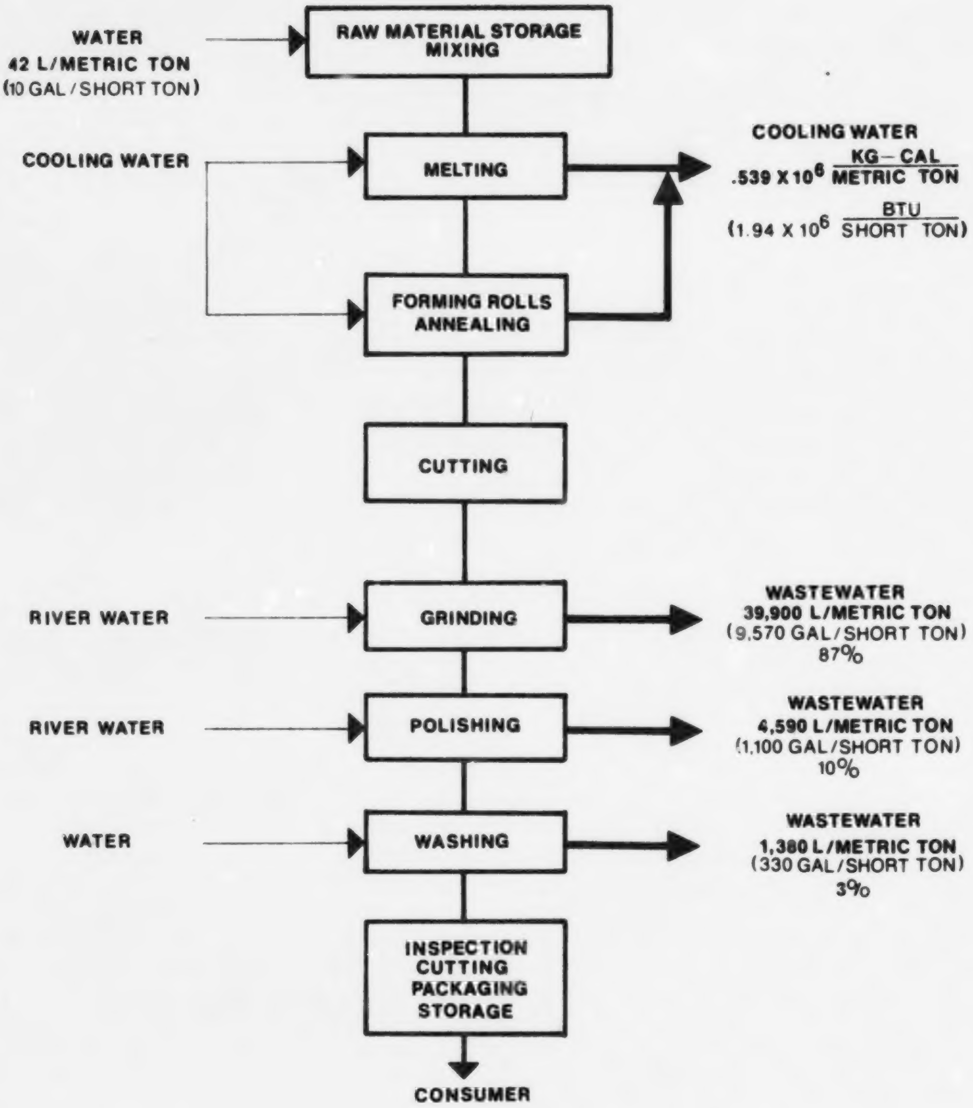
WATER
42 L/METRIC TON
(10 GAL/SHORT TON)
RAW MATERIAL STORAGE MIXING
COOLING WATER
MELTING
COOLING WATER
.539 X 10^6 KG–CAL / METRIC TON
(1.94 X 10^6 BTU / SHORT TON)
FORMING ROLLS ANNEALING
CUTTING
RIVER WATER
GRINDING
WASTEWATER
39,900 L/METRIC TON
(9,570 GAL/SHORT TON)
87%
RIVER WATER
POLISHING
WASTEWATER
4,590 L/METRIC TON
(1,100 GAL/SHORT TON)
10%
WATER
WASHING
WASTEWATER
1,380 L/METRIC TON
(330 GAL/SHORT TON)
3%
INSPECTION
CUTTING
PACKAGING
STORAGE
CONSUMER

FIGURE 7

PLATE GLASS MANUFACTURING

polishing medium to the glass surface and, therefore, contribute some organic matter to the waste water stream. The glass is ground first on one side and then on the other. A bedding medium is required to evenly support the glass. Plaster of paris is traditionally used for bedding; however, proprietary methods using a reusable medium have been developed for the newer polishing lines. Polishing contributes about 10% of the plate glass waste water volume. The major constituents include, rouge or cerium oxide, glass particles, felt, and calcium sulfate if plaster of paris bedding is used.

Washing-

The residue resulting from grinding and polishing is removed by a series of washing steps. River water is generally used for the first rinse, followed by an acid wash and a final rinsing with city water. The city water rinse may be followed by a deionized water rinse. Washing contributes about 3% of the plate glass waste water volume. The water is clean as compared with the grinding and polishing waste water. The initial wash contains significant suspended solids, but the final wash is very clean. Acid carry-over is quickly neutralized by the other waste streams which tend to be basic.

Waste Water Volume and Characteristics

Some typical characteristics for the combined waste water stream are listed in Table 5. In all cases except for pH, the values listed are the quantities added to the water as a result of the plate glass process, and concentrations in the influent water have been subtracted.

Flow--A variable volume of process water is used for plate glass manufacturing. Flows range from 14,600 to 45,900 l/metric ton (3,500 to 11,000 gal/short ton) or 4,920 to 18,200 cu m/day (1.3 to 4.8 mgd). The typical flow is 45,900 l/metric ton (11,000 gal/short ton). Water usage is related to the type and age of the equipment used, with the highest water usage at the oldest plants. At plants built before water conservation and pollution control were widely practiced, open channels were provided for flushing away any wastes or spillage. Large quantities of water are necessary to maintain sufficient velocity to prevent settling. Extensive in-plant modifications will be required in these plants to significantly reduce water usage.

Suspended solids--Suspended solids are the major waste water constituents resulting from plate glass manufacture. The available data shows a wide variation in concentration, but good correlation in terms of pounds per ton. Approximately 690 kg/metric ton (1,375 lb/short ton) of suspended solids are discharged. The major waste water source is the grinding operation, with lesser quantities contributed by polishing and washing.

TABLE 5
RAW WASTEWATER (a)
PLATE GLASS MANUFACTURING PROCESS

Flow	45,900	l/metric ton	11,000	gal/short ton		
pH	9					
Temperature (b)	2.8 C		6 F			
Suspended Solids	690	kg/metric ton	1,375	lb/short ton	15,000	mg/l
COD (b)	4.6	kg/metric ton	9.2	lb/short ton	100	mg/l
Dissolved Solids (b)	8.0	kg/metric ton	16.1	lb/short ton	175	mg/l

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(a) Represents typical plate glass process wastewater prior to treatment. Absolute value given for pH, increase over plant influent level given for other parameters.

(b) Indication of approximate level only; insufficient data are available to define actual level.

Other parameters--Limited information is available on other raw water parameters. Although sufficient information is not available to definitely establish the dissolved solids, BOD, COD, and temperature levels, the data indicate these are insignificant as compared with suspended solids. Detergents are not used and, therefore, no increase in phosphorus should occur. While some lubricating oil dripping can be expected from the process equipment, it cannot be detected in the large volume of waste water.

Discussion--Plate glass manufacturing is generally a continuous operation (24 hr/day 7 day/week), and the waste water flows, therefore, are relatively constant. Polishing is done only part of the time in some plants, and the suspended solids loadings are lower when polishing is not on line but the waste water flow is not substantially reduced. Waste water flows and characteristics are also not significantly different during start-up or shutdown. The plate furnace is drained every three to five years for rebuilding. At this time, the glass is drained into a quench tank and cooled with water. Generally the quench water evaporates and no discharge occurs. No toxic materials are known to be contained in waste water from the plate glass manufacturing process.

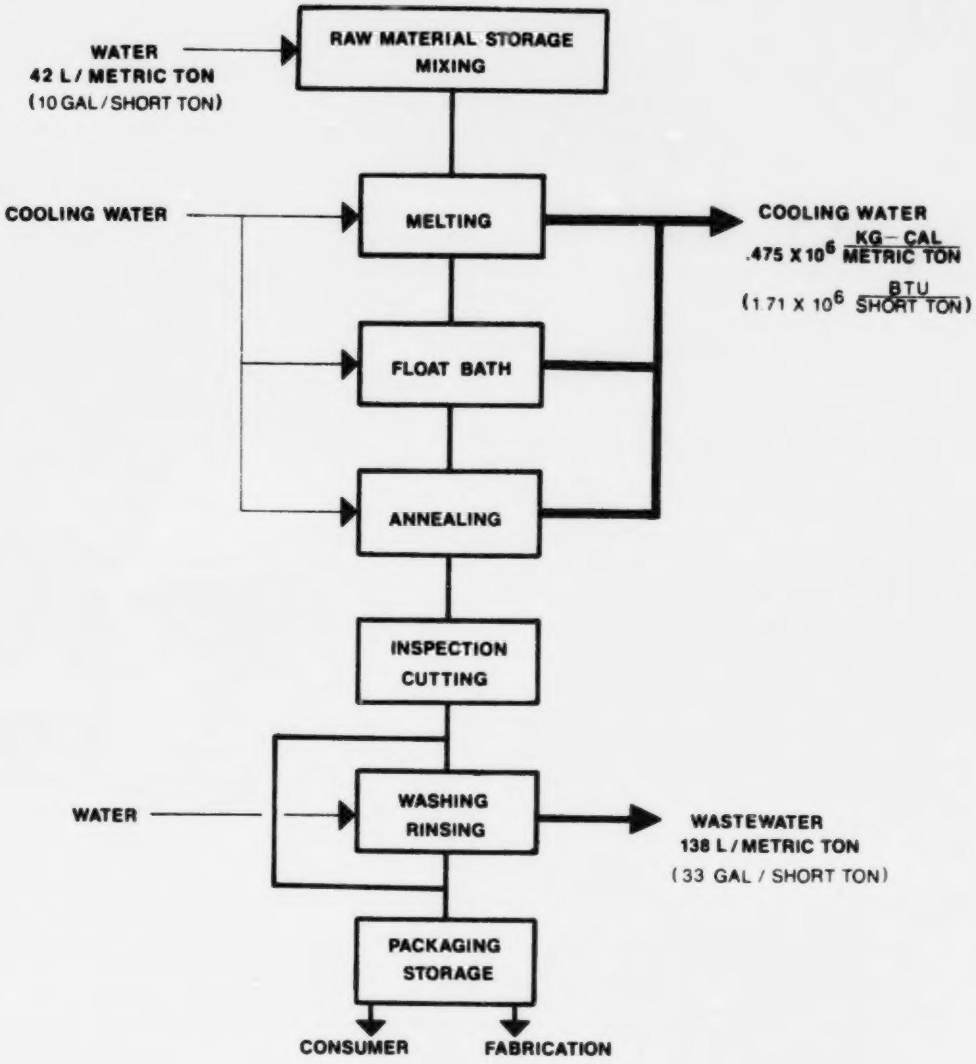
Cooling

In the plate glass manufacturing process, cooling water is required for the melting tank forming rolls, annealing lehr and compressors. Two of the three plate glass plants in the United States reported heat-rejection data. They are 311,000 kg-cal/metric ton (1,120,000 Btu/short ton) and 766,000 kg-cal/metric ton (2,760,000 Btu/short ton). The wide variation in the two values cannot be explained. The larger value is probably more representative of actual plate glass heat rejection requirements.

FLOAT GLASS MANUFACTURING

The float process may be considered the replacement for plate glass manufacturing. Float glass production is substantially less expensive and process waste water has all but been eliminated. The major process steps and points of water usage are illustrated in Figure 8. The manufacturing process is more fully explained in Section IV.

The typical float glass plant may be located in any part of the country and has been built since 1960. Both float and mirror washing are practiced so that flows are approximately 30% higher than if float washing alone is practiced. Float production is continuous seven days a week, but the mirror washer is operated only as required.



WATER
42 L / METRIC TON
(10 GAL / SHORT TON)
RAW MATERIAL STORAGE
MIXING
COOLING WATER
MELTING
COOLING WATER
.475 X 10^6 KG-CAL / METRIC TON
(1.71 X 10^6 BTU / SHORT TON)
FLOAT BATH
ANNEALING
INSPECTION
CUTTING
WATER
WASHING
RINSING
WASTEWATER
138 L / METRIC TON
(33 GAL / SHORT TON)
PACKAGING
STORAGE
CONSUMER
FABRICATION

FIGURE 8
FLOAT GLASS MANUFACTURING

Process Water and Waste Water

Process water is used in the batch and in some cases for washing. Approximately 42 l/metric ton (10 gal/short ton) of water are added to the raw materials for dust suppression. This water is evaporated in the melting tank. Some plants wash the glass prior to packing, and this constitutes the only waste water stream for this subcategory.

Washing-

Sulfur dioxide is sprayed on the underside of the glass sheet soon after forming to develop a protective coating. Sodium sulfate is formed which, in high enough quantity, will show up as a visible film on the glass which may be removed by washing.

Some plants wash as part of the float process and others do not. Generally, where they do not, the glass is to be fabricated in the same facility, and washing is the first step in the fabrication process. Glass to be used for mirror manufacture is always washed in a special washer not directly connected to the float line. The available data do not distinguish between regular washing and mirror washing, so both types are considered to be part of the float process in this report. The mirror washer effluent is probably of higher quality than the float washwater, but the differences are not significant for this study.

Two basic types of washing systems are used. Most plants presently use a one- or two-stage wash of city water quality followed by a deionized water rinse. The water is heated to 52-65°C (125-150° F) to prevent glass breakage and to enhance dissolution of the soluble film. Maximum recycle is practiced, with blowdown governed by dissolved solids buildup. This system is typical of the industry.

An older three-stage system using detergents is still used at some plants. The first stage is a recycled detergent wash followed by a recycled city-water rinse and a recycled deionized-water rinse. Blowdown is governed by dissolved solids and detergent buildup.

Waste Water Volume and Characteristics

Some typical characteristics of float-glass washwater blowdown are listed in Table 6. In all cases except for pH, the values listed are the quantities added to the water as a result of the float glass process, and concentrations in the influent water have been subtracted.

Flow--The volume of washwater discharge is influenced by make-up water characteristics and mirror washing requirements. Flows range from 88 to 138 l/metric ton (21 to 33 gal/short ton) or 34 to 136 cu m/day (0.009 to 0.036 mgd), with the highest volumes recorded for plants that are washing mirror glass. The typical

TABLE 6
RAW WASTEWATER (a)
FLOAT GLASS MANUFACTURING PROCESS

Flow	138	1/metric ton	33	gal/ton		
pH	8					
Temperature (b)	37 C		98 F			
Suspended Solids	2	g/metric ton	.0041	lb/short ton	15	mg/1
Oil	.7	g/metric ton	.0014	lb/short ton	5	mg/1
COD	2	g/metric ton	.0041	lb/short ton	15	mg/1
BOD	.25	g/metric ton	.0005	lb/short ton	2	mg/1
Phosphorus	(c)					
Dissolved Solids	14	g/metric ton	.028	lb/short ton	100	mg/1

(a) Representative of typical float glass process wastewater. Absolute value given for pH and temperature, increase over plant influent level given for other parameters.

(b) Indication of approximate level only; insufficient data is available to define actual level.

(c) No information is available on wastewater containing phosphorus.

flow is 138 l/metric ton (33 gal/ton). The volume of waste water discharged depends upon the dissolved-solids content of the make-up water. Blowdown rates are manually adjusted and are generally held constant even though the square meters of glass washed may vary considerably. The flow is set so that acceptable dissolved solids concentrations are maintained at the highest washing rate. Dissolved solids in the wash prior to the deionized rinse are generally limited to 300 to 400 mg/l.

Waste water parameters--Blowdown from the float washer is of fairly high quality, as can be seen from Table 6. The most significant increase of 14 g/metric ton (0.028 lb/short ton) or 100 mg/l is noted for dissolved solids. COD and suspended solids show increases of only 2 g/metric ton (0.0041 lb/short ton). Trace quantities of BOD and oil are also present. The available data indicate a pH range of 7.4-8.2 with a typical pH of 8. Only one temperature reading was available, this gives an indication of the water temperature, but should not be taken as typical. No information was available on the phosphorus content of float washer effluent where detergents are used, but the use of detergent is not typical. Deionizer regeneration is not considered process waste water and, therefore, was not included in the characterization.

Discussion--Process waste water from the float subcategory is of fairly high quality and is disposed of only because of the dissolved solids concentration. There is no significant change in waste water characteristics during start-up or shutdown. The float furnace is drained every 3 to 5 years for cleaning. Molten glass is drained into a quench tank and cooled with a water spray. The cooling water evaporates and no discharge occurs.

Cooling

In the float glass manufacturing process, cooling water is required for the melting tank, float bath, annealing lehr and the compressors. Average heat rejection is 475,000 kg-cal/metric ton (1,710,000 Btu/short ton) removed from the melting tank with a range of 400,000 kg-cal/metric ton (1,440,000 Btu/short ton) to 561,000 kg-cal/metric ton (2,020,000 Btu/short ton).

SOLID TEMPERED AUTOMOTIVE GLASS FABRICATION

Solid tempered automotive fabrication is the fabrication from glass blanks of automobile backlights (back windows) and sidelights (side windows). The major process steps and points of water usage are illustrated in Figure 9. A detailed description of the manufacturing process is given in Section IV.

The typical solid tempered automotive glass fabrication plant may be located in any part of the country and uses process equipment that has been modified within the last 10 to 15 years. Production schedules are variable, but in many cases the plant is operated five or six days a week for 24 hours a day.

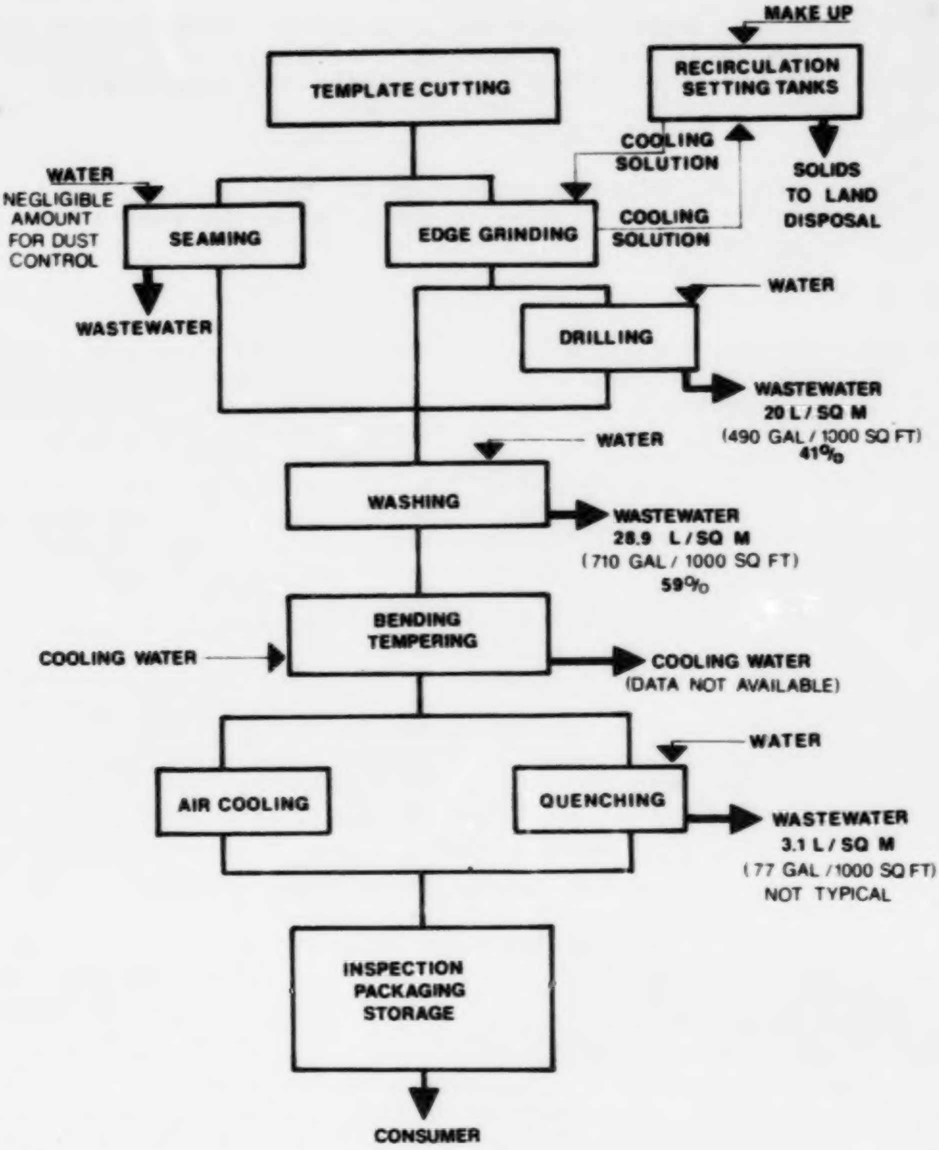

MAKE UP
RECIRCULATION SETTING TANKS
TEMPLATE CUTTING
COOLING SOLUTION
SOLIDS TO LAND DISPOSAL
WATER
NEGLIGIBLE AMOUNT FOR DUST CONTROL
SEAMING
EDGE GRINDING
COOLING SOLUTION
WASTEWATER
WATER
DRILLING
WASTEWATER 20 L / SQ M (490 GAL / 1000 SQ FT) 41%
WATER
WASHING
WASTEWATER 28.9 L / SQ M (710 GAL / 1000 SQ FT) 59%
COOLING WATER
BENDING TEMPERING
COOLING WATER (DATA NOT AVAILABLE)
WATER
AIR COOLING
QUENCHING
WASTEWATER 3.1 L / SQ M (77 GAL / 1000 SQ FT) NOT TYPICAL
INSPECTION PACKAGING STORAGE
CONSUMER

FIGURE 9

SOLID TEMPERED AUTOMOTIVE GLASS FABRICATION

Process Water and Waste Water

Water is used in solid tempered automotive fabrication for seaming, grinding, drilling, quenching, cooling, and washing. The washwater is the major source of contaminated waste water.

Seaming-

Seaming is a light grinding to remove the sharp edges on backlights. In some cases, a fine spray of water is used to hold down the dust.

Edge Grinding-

Edge grinding is used to form the smooth rounded edge on the exposed surfaces of sidelights. An oil-water emulsion coolant-solution is used which also serves to flush away the glass particles. All plants recycle the coolant through a gravity sedimentation chamber where the glass particles settle and are removed along with free floating oil and scum. The coolant is continuously recycled and the only blowdown from the system is the carry-over that remains on the glass. In the typical plant, the settled sludge and skimmings are collected for disposal as landfill; a few plants, however, discharge this waste to the waste water system. About 11.2 g/sq m (2.3 lb/1000 sq ft) of dry sludge is produced.

Drilling-

Holes are drilled in sidelights for window handles and brackets. Water is used in this process to cool the drill and to flush away the glass particles. The typical flow is 20 l/sq m (490 gal/1000 sq ft).

Washing-

Washing is required to remove residual coolant and glass particles. One or two washing steps may be used before the bending furnace, depending on the plant set up. Where the plant is set up on a production-line basis, the glass goes directly from edge grinding through drilling and washing to tempering, and only one washer is used. The edging or drilling and seaming lines may also operate independently of the tempering line, in which case washing occurs following drilling and seaming and again before tempering. More water is used in the two-stage process, but the pollutant loadings are not significantly different.

Both once-through and recycling washers are used, two or more stages may be used with each recycling from its own reservoir. Make-up water is added to the last stage and waste water is discharged from the first stage. The recycle systems reduce the water usage, but the quantity of waste products is not reduced. The washwater is heated to accelerate removal of oily residues.

Recycling is limited by the build-up of oil and suspended solids. A typical plant uses one or two wash steps, with some recycling. The typical flow is 28.9 l/sq m (710 gal/1000 sq ft).

Quenching-

Rapid cooling is required by the tempering process. Air cooling is typical, but quenching is also done with a water spray. Quench water is considered a process waste because the water comes in direct contact with the glass. Very little, if any, contaminants are picked up. The only apparent benefit of water quenching is that less space is required than for air cooling. About 3.1 l/sq m (77 gal/1000 sq ft) is used where quenching is employed.

Waste Water Volume and Characteristics

Some typical characteristics of the combined waste water resulting from solid tempered automotive fabrication are listed in Table 7. In all cases except for pH, the values listed are the quantities added to the water as a result of solid tempered automotive fabrication. The background level in the influent water has been subtracted. The significant parameters are BOD, suspended solids, and oil.

Flow--Process waste water flows vary significantly, ranging from 40.7-105 l/sq m (1000 to 2,600 gal/1000 sq ft) or 492-1551 cu m/day (0.13 to 0.41 mgd). The typical flow is considered to be 49 l/sq m (1200 gal/1000 sq ft). As stated above, the waste water flow rates are influenced both by the number of washing steps employed and by recycling. The high flow-rate is indicative of a plant which does not recycle water.

Suspended solids--Suspended solids are added to the waste stream in the form of glass particles resulting from seaming, grinding, and drilling. A typical plant generates 4.9 g/sq m (1 lb/1000 sq ft). Some decrease in suspended solids loading may be expected if dry seaming is practiced, but a quantitative estimate of the reduction is not available.

Oil--Almost all the oil is contributed by the grinding solution carry-over, with trace quantities added by miscellaneous machine lubricants. Typical plant waste water contains 0.64 g/sq m (0.13 lb/1000 sq ft).

Biochemical Oxygen Demand--A small quantity of BOD is contributed to the waste water by the oil in the coolant solution carry-over and to a much lesser extent by traces of oil entering the waste-water stream as a result of machinery lubrication. The typical raw waste water loading is 0.73 g/sq m (0.15 lb/1000 sq ft).

Other parameters--Some information is also available on pH, temperature, COD, and dissolved solids. Limited data are available for temperature and COD, but 8°C (17°F) and 1.22 g/sq m (0.25 lb/

TABLE 7
RAW WASTEWATER (a)
SOLID TEMPERED AUTOMOTIVE GLASS FABRICATION

Flow	49	l/sq m	1200	gal/1000 sq ft		
pH	7					
Temperature (b)	8 C		17 F			
Suspended Solids	4.9	g/sq m	1	lb/1000 sq ft	100	mg/l
Oil	.64	g/sq m	.13	lb/1000 sq ft	13	mg/l
COD (b)	1.22	g/sq m	.25	lb/1000 sq ft	25	mg/l
BOD	.73	g/sq m	.15	lb/1000 sq ft	15	mg/l
Dissolved Solids	4.9	g/sq m	1	lb/1000 sq ft	100	mg/l

(a) Representative of typical solid tempered automotive process wastewater. Absolute value given for pH, increase over plant influent level given for other parameters.

(b) Indication of approximate level only; insufficient data is available to define actual level.

1000 sq ft) are indicative of the increases to be expected. A pH of nearly 7 was recorded in all cases, indicating that pH is not a problem in solid tempered automotive glass fabrication. The dissolved solids increase of 4.9 g/sq m (1 lb/1000 sq ft) is higher than was expected. Water treatment regenerants and boiler blowdown (which are combined with the process waste water stream for much of the sample data) are assumed to have contributed at least in part to the dissolved solids increase.

Discussion--No significant variations in waste water volume or characteristics are experienced during plant start-up or shutdown, and there are no known toxic materials in waste water from the solid tempered automotive glass manufacturing process.

Cooling

Cooling water is required at some solid tempered automotive glass plants for the tempering hearth and quenching. Although no data is available, heat rejection for these operations can be expected to be low with respect to the other subcategories.

WINDSHIELD FABRICATION

Windshield fabrication is the manufacturing of laminated windshields from glass blanks and vinyl plastic. Oil resulting from oil autoclaving is the major constituent in this waste water. The major process steps and points of water usage are illustrated in Figure 10. A detailed description of the manufacturing process is given in Section IV.

The typical windshield fabrication plant may be located in any part of the country and uses oil autoclaves. Air autoclaves have been installed at some new plants, but oil autoclaves are still used for 90% of the windshields produced. The production schedule is variable and ranges from an eight hour five-day week to a 24 hour six-day week.

Process Water and Waste Water

Water is used in windshield fabrication for cooling, seaming, and washing. Three or four washes are required when oil autoclaves are used. Initial, vinyl, and post-lamination washes are required in all cases. The prelamination wash has been eliminated by some plants.

Seaming-

Wet or dry seaming may be used in the windshield fabrication process. With wet seaming, a small volume of water is used for dust control and to flush away the glass particles produced. About 8.2 l/sq m (200 gal/1000 sq ft) of finished windshields is used.

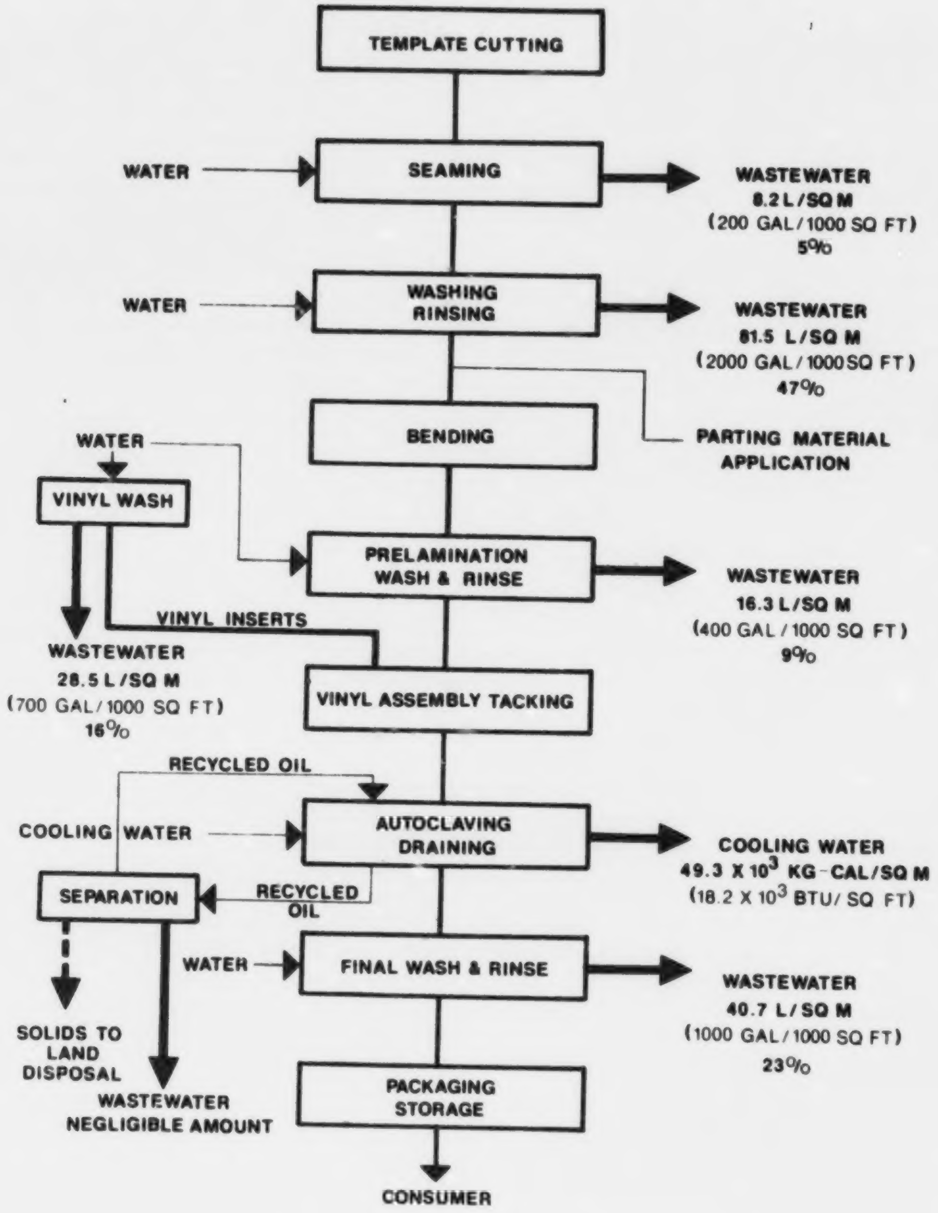

TEMPLATE CUTTING
WATER
SEAMING
WASTEWATER
8.2 L/SQ M
(200 GAL/1000 SQ FT)
5%
WATER
WASHING RINSING
WASTEWATER
81.5 L/SQ M
(2000 GAL/1000 SQ FT)
47%
BENDING
PARTING MATERIAL APPLICATION
WATER
VINYL WASH
PRELAMINATION WASH & RINSE
WASTEWATER
16.3 L/SQ M
(400 GAL/1000 SQ FT)
9%
VINYL INSERTS
WASTEWATER
28.5 L/SQ M
(700 GAL/1000 SQ FT)
16%
VINYL ASSEMBLY TACKING
RECYCLED OIL
COOLING WATER
AUTOCLAVING DRAINING
COOLING WATER
49.3 X 10³ KG-CAL/SQ M
(18.2 X 10³ BTU/SQ FT)
SEPARATION
RECYCLED OIL
WATER
FINAL WASH & RINSE
WASTEWATER
40.7 L/SQ M
(1000 GAL/1000 SQ FT)
23%
SOLIDS TO LAND DISPOSAL
WASTEWATER NEGLIGIBLE AMOUNT
PACKAGING STORAGE
CONSUMER

FIGURE 10
WINDSHIELD FABRICATION

Initial Wash-

The first wash occurs early in the manufacturing process, following cutting and seaming. Traces of cutting oil, residual glass particles, and any dust which may have accumulated on the glass while in storage is removed. Only water, which is generally heated, is used. No detergents or other cleaning compounds are required.

Various types of washers are used. In some cases, once-through washwater is discharged directly to the sewer. Newer plants generally use recycling washers to reduce water usage. The waste water flows vary from 28.5 to 138 l/sq m (700 to 3400 gal/1000 sq ft) of finished windshields. The typical flow is 81.5 l/sq m (2000 gal/1000 sq ft).

Prelamination Wash-

The two pieces of glass used to form a windshield are bent as one unit, and a parting material is used to prevent the two pieces from fusing during the bending process. The parting material is usually washed before the vinyl sheet is inserted, but in some cases a material is used that does not require washing. The exact nature of the parting materials used and the details of their application and removal are considered proprietary by the industry.

The prelamination washer also serves to clean the glass surface of any dirt or spots since they cannot be removed following lamination. A three-stage washer is usually used. The first stage is a detergent wash followed by a city-water rinse and a final demineralized-water rinse. Deionized rinse water is the only makeup to the system. It is recycled through the stages and discharged as blowdown from the detergent wash. All stages are heated. Water usage is about 16.3 l/sq m (400 gal/1000 sq ft) of windshields produced. The limited data available indicate a hot waste water with relatively high phosphorus, moderate dissolved-solids, and low organic and suspended solids increases.

Vinyl Wash-

The plastic used for laminating is shipped from the manufacturer in rolls. Sodium bicarbonate is used as a parting material to keep the plastic from sticking and is removed in a two- or three-stage washer. The three-stage system uses two city-water washes in series followed by a deionized-water rinse. The two-stage system is used where relatively low dissolved-solids water is available and consists of two city-water rinses in series. Highly variable quantities of water are used for washing plastic, ranging from 12.2 to 285 l/sq m (300 to 7000 gal/1000 sq ft). The typical flow rate is 28.5 l/sq m (700 gal/1000 sq ft). The waste water is high in dissolved solids because of the sodium bicarbonate. The data also indicate a COD of 100 mg/l or 2.8

g/sq m (0.58 lb/1000 sq ft) based on the typical flow. The high COD is unexpected and has not been explained.

Post-Lamination Wash-

Residual oil from the laminating autoclaves is removed in a series washing operation. Two basic systems are employed in the industry. In one case only washing is accomplished. In the second case, the washing is done in two stages with dry seaming in between washing steps. The waste water characteristics are similar for both systems. For the purposes of this report, both systems will be grouped and discussed as one process.

Washwater for each stage is recycled out of a reservoir. In some cases, flows are countercurrent with blowdown from the following stage serving as makeup for the preceding stage.

The old method of post-lamination washing, still used at some plants, is to use a detergent wash as the first stage followed by two city-water rinses and possibly a final deionized-water rinse. Large quantities of detergent are required with this system, and very oily emulsified waste water is produced.

Using a hot-water rinse before the detergent wash has been found to cut detergent usage by up to 95%. Most of the oil is removed by the hot water, and proportionately less detergent is required to emulsify the residual oil. Although the same quantity of oil remains in the waste water stream, the majority is free oil and is more readily removed than emulsified oil.

The waste water flows are the same for both methods. The typical post-lamination washer flow is 40.7 l/sq m (1000 gal/1000 sq ft) of windshields produced. Waste water characteristics are also similar for both methods, except higher phosphorus concentrations resulting from higher detergent usage are expected where an initial detergent wash is used.

Oil Separation System-

Small amounts of water are picked up by the autoclave oil from condensation, cooling water leaks, and other sources. The oil and water separate in the oil storage tanks and the water is removed to a second tank where further gravity separation takes place. The oil is recycled to the autoclaves and the water is either discharged to the sewer or to the autoclave washwater treatment system. The stream accounts for only one to two percent of the total waste water flow.

Waste Water Volume and Characteristics

Some typical characteristics of the combined waste water stream resulting from windshield fabrication are listed in Table 8. In all cases except for pH, the values listed are the quantities added to the water as a result of windshield fabrication. The

TABLE 8
RAW WASTEWATER (a)
WINDSHIELD FABRICATION USING OIL AUTOCLAVES

Flow	175	l/sq m	4300	gal/1000 sq ft		
pH	7-8					
Temperature	18.9 C		40 F			
Suspended Solids	4.4	g/sq m	.9	lb/1000 sq ft	25	mg/l
Oil	298	g/sq m	61	lb/1000 sq ft	1700	mg/l
COD	298	g/sq m	61	lb/1000 sq ft	1700	mg/l
BOD	5.9	g/sq m	1.2	lb/1000 sq ft	33	mg/l
Total Phosphorus	.98	g/sq m	.2	lb/1000 sq ft	5.6	mg/l

(a) Representative of typical process wastewater from the fabrication of windshields using oil autoclaves. Absolute values are listed for pH; the increase over plant influent level is given for other parameters.

influent water background levels have been subtracted. These data apply to a plant where an initial hot-water rinse is used for the post-lamination wash. No information is available for plants using an initial detergent wash.

Flow--Waste water flow rates from plants considered typical of the windshield fabrication process vary from 52.9 to 492 l/sq m (1300 to 12,100 gal/1000 sq ft) of windshields produced. This corresponds to 454 to 2195 cu m/day (0.12 to 0.58 mgd). The variability is due to the type of washers used (once-through as opposed to recycling) and to the dissolved-solids content of the plant water. Less recycling can be practiced where influent dissolved solids are high. The typical flow is 175 l/sq m (4300 gal/1000 sq ft).

Suspended solids--Suspended solids are contributed to windshield fabrication waste water as a result of seaming. Carry-over results, even when dry seaming is used. The data indicate a typical reported value of 137 g/sq m (28 lb/1000 sq ft) or 780 mg/l. This figure is much higher than the actual suspended-solids level because of oil interference since free oil tends to collect on the filter used in the suspended solids determination, causing high readings. The actual typical suspended solids are estimated at 4.4 g/sq m (0.9 lb/1000 sq ft) or 25 mg/l.

Oil--Almost all the oil is contributed by the laminating process, with trace amounts resulting from machinery lubrication. The typical loading is 298 g/sq m (61 lb/1000 sq ft).

Chemical Oxygen Demand--A significant COD is noted as a result of the high oil content from the post-lamination wash. Almost the entire loading of 298 g/sq m (61 lb/1000 sq ft) may be attributed to oil. As indicated above, some COD is also contributed by the vinyl washwater.

pH--The pH for all of the plants for which data was received ranged between 7 and 8. Sodium bicarbonate, removed from the vinyl, is the only constituent added which would be expected to significantly affect pH. Sufficient dilution is provided by the other waste waters so that little effect is noted.

Phosphorus--Phosphorus results from detergents used in the pre-assembly and post-lamination washes. The available information on phosphorus loading shows substantial variation, indicating variable detergent usage. No basis is available for defining phosphorus or detergent limitations; therefore, the typical phosphorus value is based on the plants with high phosphorus loadings. The typical value is 0.98 g/sq m (0.2 lb/1000 sq ft).

Other parameters--Limited information is available on BOD and temperature characteristics for raw windshield-lamination waste water. The data indicate a BOD loading of 5.9 g/sq m (1.2 lb/1000 sq ft) or 33 mg/l. As with COD, the BOD can be attributed to the oily waste water temperatures. These show an average discharge temperature immediately following the process of 38.9°C (102°F) or 18.9°C (40°F) over the influent temperature. Sufficient data is not available to give an indication of the dissolved-solids levels.

Discussion--No significant variations in waste water volume or characteristics are experienced during plant start-up or shut-down, and there are no known toxic materials in waste water from the windshield fabrication process.

Cooling

Cooling water is required for autoclave operations and the compressors. Data is available from two plants. Values are 40,100 kg-cal/sq m (14,800 Btu/sq ft) and 58,600 kg-cal/sq m (21,600 Btu/sq ft) of fabricated automotive glass. The average heat rejection is 49,300 kg-cal/sq m (18,200 Btu/sq ft).

SECTION VI

SELECTION OF POLLUTANT PARAMETERS

Subcategories causing significant pollution in this portion of the flat glass industry are plate glass manufacturing, solid tempered automotive, and windshield fabrication. The major waste water constituents are the result of various types of grinding and oil autoclaving. Less significant dissolved-solids are contributed by parting materials used at several points in these processes for glass or plastic separation.

MAJOR PARAMETERS

The major parameters of pollutional significance for the combined group of subcategories are:

Total Suspended Solids (TSS)

Oil and Grease

pH

Total Phosphorus

Other parameters contained in process waste waters from the flat glass segment of the glass industry are BOD, COD, detergents, temperature and dissolved solids.

The above parameters do not occur in all cases for all subcategories, or may be less significant in one subcategory than in another. Table 9 lists the typical concentrations by subcategory. These are the only constituents known to be added. On the basis of the data collected, no toxic or hazardous substances are contained in these process waste waters.

TOTAL SUSPENDED SOLIDS (TSS)

Suspended solids include both organic and inorganic materials. The inorganic components include sand, silt, and clay. The organic fraction includes such materials as grease, oil, tar, animal and vegetable fats, various fibers, sawdust, hair, and various materials from sewers. These solids may settle out rapidly and bottom deposits are often a mixture of both organic and inorganic solids. They adversely affect fisheries by covering the bottom of the stream or lake with a blanket of material that destroys the fish-food bottom fauna or the spawning ground of fish. Deposits containing organic materials may deplete bottom oxygen supplies and produce hydrogen sulfide, carbon dioxide, methane, and other noxious gases.

In raw water sources for domestic use, state and regional agencies generally specify that suspended solids in streams shall not be present in sufficient concentration to be objectionable or

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TABLE 9
CONCENTRATION OF WASTEWATER PARAMETERS
PRIMARY FLAT GLASS MANUFACTURING AND AUTOMOTIVE GLASS FABRICATION

	TYPICAL RAW WASTEWATER CONCENTRATION (a)					
	Rolled Glass	Sheet Glass	Plate Glass	Float Glass	Solid Tempered Automotive	Windshield Fabrication
Suspended Solids, mg/l	no process wastewater	no process wastewater	15,000	15	100	25
Oil, mg/l			trace	5	13	1,700
COD, mg/l			100(b)	15	25	1,700
BOD, mg/l			(c)	2	15	33
pH			9	8	7	7-8
Total Phosphorus, mg/l			no increase	no increase	no increase	5
Temperature F			6(b)	moderate(c)	17(b)	40(b)
Dissolved Solids, mg/l(d)			175(b)	100	100	low(c)

(a) Increase over background concentration for all parameters except for pH.

(b) Based on limited data, indication of typical value only.

(c) Insufficient data to define.

(d) In some cases, dissolved solids influenced by auxiliary wastes.

to interfere with normal treatment processes. Suspended solids in water may interfere with many industrial processes, and cause foaming in boilers, or encrustations on equipment exposed to water, especially as the temperature rises. Suspended solids are undesirable in water for textile industries; paper and pulp; beverages; dairy products; laundries; dyeing; photography; cooling systems, and power plants. Suspended particles also serve as a transport mechanism for pesticides and other substances which are readily sorbed into or onto clay particles.

Solids may be suspended in water for a time, and then settle to the bed of the stream or lake. These settleable solids discharged with man's wastes may be inert, slowly biodegradable materials, or rapidly decomposable substances. While in suspension, they increase the turbidity of the water, reduce light penetration and impair the photosynthetic activity of aquatic plants.

Solids in suspension are aesthetically displeasing. When they settle to form sludge deposits on the stream or lake bed, they are often much more damaging to the life in water, and they retain the capacity to displease the senses. Solids, when transformed to sludge deposits, may do a variety of damaging things, including blanketing the stream or lake bed and thereby destroying the living spaces for those benthic organisms that would otherwise occupy the habitat. When of an organic and therefore decomposable nature, solids use a portion or all of the dissolved oxygen available in the area. Organic materials also serve as a seemingly inexhaustible food source for sludgeworms and associated organisms.

Turbidity is principally a measure of the light absorbing properties of suspended solids. It is frequently used as a substitute method of quickly estimating the total suspended solids when the concentration is relatively low.

Suspended solids are contained at various concentrations in plate, float, and automotive fabrication waste waters. Typical raw waste concentrations range from 15 mg/1 for float to 15,000 mg/1 for plate glass manufacturing.

OIL AND GREASE

Oil and grease exhibit an oxygen demand. Oil emulsions may adhere to the gills of fish or coat and destroy algae or other plankton. Deposition of oil in the bottom sediments can serve to inhibit normal benthic growths, thus interrupting the aquatic food chain. Soluble and emulsified material ingested by fish may taint the flavor of the fish flesh. Water soluble components may exert toxic action on fish. Floating oil may reduce the reaeration of the water surface and in conjunction with emulsified oil may interfere with photosynthesis. Water insoluble components damage the plumage and costs of water animals and fowls. Oil and grease in a water can result in the formation of objectionable surface slicks preventing the full aesthetic enjoyment of the water.

Oil spills can damage the surface of boats and can destroy the aesthetic characteristics of beaches and shorelines.

Oil is contributed to flat glass waste waters as a result of laminating, edge grinding, and miscellaneous machinery lubrication. At least traces of oil appear in all process waste water, but significant quantities are contained in solid tempered automotive and windshield fabrication wastes. The State of Illinois limits oil discharge to 15 mg/l. Public Health Service Drinking Water Standards, by limiting carbon chloroform extract (CCE) to 0.2 mg/l, allow virtually no oil concentration in drinking water. Raw waste water concentrations in this study range from traces resulting from machinery lubrication to 13 mg/l for solid tempered automotive and 1700 mg/l for windshield fabrication.

pH, ACIDITY AND ALKALINITY

Acidity and alkalinity are reciprocal terms. Acidity is produced by substances that yield hydrogen ions upon hydrolysis and alkalinity is produced by substances that yield hydroxyl ions. The terms "total acidity" and "total alkalinity" are often used to express the buffering capacity of a solution. Acidity in natural waters is caused by carbon dioxide, mineral acids, weakly dissociated acids, and the salts of strong acids and weak bases. Alkalinity is caused by strong bases and the salts of strong alkalies and weak acids.

The term pH is a logarithmic expression of the concentration of hydrogen ions. At a pH of 7, the hydrogen and hydroxyl ion concentrations are essentially equal and the water is neutral. Lower pH values indicate acidity while higher values indicate alkalinity. The relationship between pH and acidity or alkalinity is not necessarily linear or direct.

Waters with a pH below 6.0 are corrosive to water works structures, distribution lines, and household plumbing fixtures and can thus add such constituents to drinking water as iron, copper, zinc, cadmium and lead. The hydrogen ion concentration can affect the "taste" of the water. At a low pH water tastes "sour". The bactericidal effect of chlorine is weakened as the pH increases, and it is advantages to keep the pH close to 7. This is very significant for providing safe drinking water.

Extremes of pH or rapid pH changes can exert stream conditions or kill aquatic life outright (ammonia is more lethal with a higher pH). Dead fish, associated algal blooms, and four stenches are aesthetic liabilities of any waterway. Even moderate changes from "acceptable" criteria limits of pH are deleterious to some species. The relative toxicity to aquatic life of many materials is increased by changes in the water pH. Metalocyanide complexes can increase a thousand-fold in toxicity with a drop of 1.5 pH units. The availability of many nutrient substances varies with the alkalinity and acidity.

The lacrimal fluid of the human eye has a pH of approximately 7.0 and a deviation of 0.1 pH unit from the norm may result in eye irritation for the swimmer. Appreciable irritation will cause severe pain.

Except for plate glass manufacturing, pH is not a significant pollutant in the flat glass industry. pH levels of 6-9 are generally considered acceptable, and these are readily achieved in all the other subcategories. Plate glass wastes tend to be alkaline, and in some plants acid treatment is used to reduce the pH to 9.

PHOSPHORUS

Phosphorus is contributed to the windshield waste water stream and, in some cases, to float waste water through the use of detergents. During the past 30 years, a formidable case has developed for the belief that increasing standing crops of aquatic plant growths, which often interfere with water uses and are nuisances to man, frequently are caused by increasing supplies of phosphorus. Such phenomena are associated with a condition of accelerated eutrophication or aging of waters. It is generally recognized that phosphorus is not the sole cause of eutrophication, but there is evidence to substantiate that it is frequently the key element in all of the elements required by fresh water plants and is generally present in the least amount relative to need. Therefore, an increase in phosphorus allows use of other, already present, nutrients for plant growths. Phosphorus is usually described, for this reason, as a "limiting factor".

When a plant population is stimulated in production and attains a nuisance status, a large number of associated liabilities are immediately apparent. Dense populations of pond weeds make swimming dangerous. Boating and water skiing and sometimes fishing may be eliminated because of the mass of vegetation that serves as a physical impediment to such activities. Plant populations have been associated with stunted fish populations and with poor fishing. Plant nuisances emit vile stenches, impart tastes and odors to water supplies, reduce the efficiency of industrial and municipal water treatment, impair aesthetic beauty, reduce or restrict resort trade, lower waterfront property values, cause skin rashes to man during water contact, and serve as a desired substrate and breeding ground for flies. Total phosphorus is also a measure of detergent usage.

OTHER PARAMETERS

As mentioned above, there are other parameters which are contained in process waste waters in the flat glass industry:

BOD, COD, detergents, temperature, and dissolved solids. Both BOD and COD are intended to be measures of the organic content of a water or waste water, and are described below.. In the flat glass industry, BOD and COD are contributed mainly by oil and grease, and suspended solids. However, soluble BOD and COD are already present in many cases in water used in flat glass processes. The concentrations are often significant when compared to the COD and BOD added by the processes. Therefore, these measurements are not appropriate for pollution control in the flat glass industry. The organic matter added by the processes is adequately described by the oil and grease, and suspended solids parameters.

As described below, dissolved solids are added by various processes but the technology to control these substances are extremely expensive and complex. Moreover, the solid wastes generated are difficult to dispose of and often pose more of an environmental problem than if they remained in process waste waters. The control technology is fully described in Section VII.

CHEMICAL OXYGEN DEMAND (COD)

COD is a measure of the oxygen consuming capabilities of organic matter. It measures the amount of organic and some inorganic pollutants under a carefully controlled direct chemical oxidation by a dichromate-sulfuric acid reagent. COD is a much more rapid measure of oxygen demand than BOD_5, and is potentially very useful. However, it does not have the same significance, and at the present time cannot be substituted for BOD_5 because $COD:BOD_5$ ratios vary with the types of wastes.

COD provides a rapid determination of the waste strength. Its measurement will indicate a serious plant or treatment malfunction long before the BOD_5 can be run. A given plant or waste treatment system usually has a relatively narrow range of $COD:BOD_5$ ratios, if the waste characteristics are fairly constant, so experience permits a judgment to be made concerning plant operation from COD values.

Some COD is contributed by all of the process waste waters, and the values range from 15 mg/l for float glass to 1700 mg/l for the typical windshield fabrication plant. In most cases, COD is a direct result of the oil concentration. Because BOD concentrations are low, COD is a more accurate measure of organic content for flat glass waste water.

BIOCHEMICAL OXYGEN DEMAND (BOD)

Biochemical oxygen demand (BOD) is another measure of oxygen demand. The BOD does not in itself cause direct harm to a water system, but it does exert an indirect effect by depressing the oxygen content of the water. Sewage and other organic effluents during their processes of decomposition exert a BOD, which can have a catastrophic effect on the ecosystem by depleting the oxygen supply. Conditions are reached frequently where all of the oxygen is used and the continuing decay process causes the production of noxious gases such as hydrogen sulfide and methane. Water with a high BOD indicates the presence of decomposing organic matter and subsequent high bacterial counts that degrade its quality and potential uses.

If a high BOD is present, the quality of the water is usually visually degraded by the presence of decomposing materials and algae blooms due to the uptake of degraded materials that form the foodstuffs of the algal populations. Dissolved oxygen (DO) is a water quality constituent that, in appropriate concentrations, is essential not only to keep organisms living but also to sustain species reproduction, vigor, and the development of populations. Organisms undergo stress at reduced D.O. concentrations that make them less competitive and able to sustain their species within the aquatic environment. For example, reduced DO concentrations have been shown to interfere with fish population through delayed hatching of eggs, reduced size and vigor of embryos, production of deformities in young, interference with food digestion, acceleration of blood clotting, decreased tolerance to certain toxicants, reduced food efficiency and growth rate, and reduced maximum sustained swimming speed. Fish food organisms are likewise affected adversely in conditions with suppressed DO. Since all aerobic aquatic organisms need a certain amount of oxygen, the consequences of total lack of dissolved oxygen due to a high BOD can kill all inhabitants of the affected area.

At least trace concentrations of BOD are present in all of the process waste streams. Insignificant loadings occur for plate and float glass and at least measurable concentrations are recorded for solid tempered automotive and windshield fabrication. BOD is inferior to COD as a measure of organic pollution, because of the low concentrations recorded in the flat glass industry and the absence of organic loading, except for oil.

TEMPERATURE

Temperature is one of the most important and influential water quality characteristics. Temperature determines those species that may be present; it activates the hatching of young, regulates their activity, and stimulates or suppresses their growth and development; it attracts, and may kill when the water becomes too hot or becomes chilled too suddenly. Colder water generally suppresses development. Warmer water generally accelerates activity and may be a primary cause of aquatic plant nuisances when other environmental factors are suitable.

Temperature is a prime regulator of natural processes within the water environment. It governs physiological functions in organisms and, acting directly or indirectly in combination with other water quality constituents, it affects aquatic life with each change. These effects include chemical reaction rates, enzymatic functions, molecular movements, and molecular exchanges between membranes within and between the physiological systems and the organs of an animal.

Chemical reaction rates vary with temperature and generally increase as the temperature is increased. The solubility of gases in water varies with temperature. Dissolved oxygen is decreased by the decay or decomposition of dissolved organic substances and the decay rate increases as the temperature of the water increases reaching a maximum at about 30°C (86°F). The temperature of stream water, even during summer, is below the optimum for pollution-associated bacteria. Increasing the water temperature increases the bacterial multiplication rate when the environment is favorable and the food supply is abundant.

Reproduction cycles may be changed significantly by increased temperature because this function takes place under restricted temperature ranges. Spawning may not occur at all because temperatures are too high. Thus, a fish population may exist in a heated area only by continued immigration. Disregarding the decreased reproductive potential, water temperatures need not reach lethal levels to decimate a species. Temperatures that favor competitors, predators, parasites, and disease can destroy a species at levels far below those that are lethal.

Fish food organisms are altered severely when temperatures approach or exceed 90°F. Predominant algal species change, primary production is decreased, and bottom associated organisms may be depleted or altered drastically in numbers and distribution. Increased water temperatures may cause aquatic plant nuisances when other environmental factors are favorable.

Synergistic actions of pollutants are more severe at higher water temperatures. Given amounts of domestic sewage, refinery wastes, oils, tars, insecticides, detergents, and fertilizers more rapidly deplete oxygen in water at higher temperatures, and the respective toxicities are likewise increased.

When water temperatures increase, the predominant algal species may change from diatoms to green algae, and finally at high temperatures to blue-green algae, because of species temperature preferentials. Blue-green algae can cause serious odor problems. The number and distribution of benthic organisms decreases as water temperatures increase above 90°F, which is close to the tolerance limit for the population. This could seriously affect certain fish that depend on benthinc organisms as a food source.

The cost of fish being attracted to heated water in winter months may be considerable, due to fish mortalities that may result when the fish return to the cooler water.

Rising temperatures stimulate the decomposition of sludge, formation of sludge gas, multiplication of saprophytic bacteria and fungi (particularly in the presence of organic wastes), and the consumption of oxygen by putrefactive processes, thus affecting the esthetic value of a water course.

In general, marine water temperatures do not change as rapidly or range as widely as those of freshwaters. Marine and estuarine fishes, therefore, are less tolerant of temperature variation. Although this limited tolerance is greater in estuarine than in open water marine species, temperature changes are more important to those fishes in estuaries and bays than to those in open marine areas, because of the nursery and replenishment functions of the estuary that can be adversely affected by extreme temperature changes.

Most of the washing operations in flat glass manufacturing and fabrication require warm-to-hot water and at least one stage of the washwater is generally heated. Some data on water temperatures immediately following the washers has been presented in this report. Temperature increases at this point are much greater than at the end of the pipe immediately before the receiving stream. Dilution with once-through cooling water and natural cooling in the sewer pipe tend to reduce discharge temperatures to less than 4.7°C (10° F) over ambient. Substantial temperature increases may adversely affect aquatic organisms; insufficent data is available at the present time, however, upon which to base limitations. These will be set at a later date.

DISSOLVED SOLIDS

In natural waters the dissolved solids consist mainly of carbonates, chlorides, sulfates, phosphates, and possibly nitrates of calcium, magnesium, sodium, and potassium, with traces of iron, manganese and other substances.

Many communities in the United States and in other countries use water supplies containing 2000 to 4000 mg/l of dissolved salts, when no better water is available. Such waters are not palatable, may not quench thirst, and may have a laxative action on new users. Waters containing more than 4000 mg/l of total salts are generally considered unfit for human use, although in hot climates such higher salt concentrations can be tolerated whereas they could not be in temperate climates. Waters containing 5000 mg/l or more are reported to be bitter and act as bladder and intestinal irritants. It is generally agreed that the salt concentration of good, palatable water should not exceed 500 mg/l.

Limiting concentrations of dissolved solids for fresh-water fish may range from 5,000 to 10,000 mg/l, according to species and prior acclimatization. Some fish are adapted to living in more saline waters, and a few species of fresh-water forms have been found in natural waters with a salt concentration of 15,000 to 20,000 mg/l. Fish can slowly become acclimatized to higher salinities, but fish in waters of low salinity cannot survive sudden exposure to high salinities, such as those resulting from discharges of oil-well brines. Dissolved solids may influence the toxicity of heavy metals and organic compounds to fish and other aquatic life, primarily because of the antagonistic effect of hardness on metals.

Waters with total dissolved solids over 500 mg/l have decreasing utility as irrigation water. At 5,000 mg/l water has little or no value for irrigation.

Dissolved solids in industrial waters can cause foaming in boilers and cause interference with cleaness, color, or taste of many finished products. High contents of dissolved solids also tend to accelerate corrosion.

Specific conductance is a measure of the capacity of water to convey an electric current. This property is related to the total concentration of ionized substances in water and water temperature. This property is frequently used as a substitute method of quickly estimating the dissolved solids concentration.

Dissolved solids are critical for all washing operations, and the concentrations must be kept low enough so that spotting of the glass does not occur. Deionized water is used in some cases for a final rinse. Because low dissolved solids is a process consideration, relatively small concentrations of dissolved solids are discharged in the process waste water. Glass is inert and, therefore, dissolved-solids sources are limited to calcium sulfate in the plate process, sodium sulfate in the float process, various parting materials used in fabrication, and to concentration increases due to evaporation. Owing to the relatively low concentration, limited dissolved-solids data have been collected by the industry. Much of the industry includes the auxiliary wastes in the process-waste stream, making it difficult to determine the dissolved solids contributed by the process. The contribution by auxiliary wastes, which are not covered by this study, is generally more significant. The major concern for dissolved solids is in a recycle system where removal is necessary because of the low washwater dissolved-solids requirements.

SECTION VII

CONTROL AND TREATMENT TECHNOLOGY

As indicated in Chapter V, the major constituents requiring treatment for primary flat glass manufacturing and automotive fabrication are suspended solids and oil. The treatment methods presently employed have been developed for this purpose. Effluent values are given as monthly averages except as noted.

No process waste water and, therefore, no treatment is required for the rolled and sheet subcategories. In all cases, polyelectrolyte addition with lagoon sedimentation is practiced for plate glass manufacturing. Upgrading the lagoon system and partial recycle are methods of reducing waste loads from the plate process. Float waste water contains pollutants in fairly low concentrations and presently is not treated. Solid tempered automotive glass waste water is also not treated but oil and suspended solids must be reduced. Flotation and centrifugation are used to reduce the oil discharged by the windshield fabrication process. Additional treatment will further reduce and assure low discharge levels in the flat glass industry. In some cases, treatment technologies developed for other industries will have to be used.

SHEET AND ROLLED GLASS MANUFACTURING

No process waste water is produced by the sheet and rolled glass subcategories. The manufacturing processes are dry with process water used only in the batch for dust control.

Both subcategories have significant cooling requirements and use substantial quantities of cooling water. Although cooling systems are not specifically covered in this report, one system related to water pollution control will be discussed briefly.

Several sheet glass plants are eliminating a pollution problem by disposing of chromium treated cooling tower blowdown in the batch. Approximately 42 l/metric ton (10 gal/short ton) can be disposed of by this method. This is especially interesting in view of the adverse affect of chromium on glass quality. At a low concentration, which has not been defined, chromium causes "stones" or imperfections in the glass. Apparently, this concentration is not exceeded in sheet glass or, more likely, the imperfections are not significant because the glass is thinner and of lower quality than other types of primary glass.

Discussions with glass industry personnel have indicated great reluctance to consider disposal of cooling tower blowdown, especially chromium treated, in the batch for plate, float, or rolled glass. These glasses are thicker and of higher quality and it is thought that noticeable imperfections in the glass will result. An unsuccessful attempt at batch disposal could be quite costly. Glass melting is a continuous process with a large volume of melted glass contained in the furnace. If an undesirable concentration of some contaminant is introduced into the glass furnace, it might result in a week or two of production of unusable glass to dilute the furnace contents to an acceptable level.

Disposal of other glass plant auxiliary wastes in the batch such as boiler blowdown and softener and deionizer regenerants is also within the realm of possibility, however, none of these has as yet been demonstrated. Washwater, especially from the float process, should also be amenable to batch disposal. Although batch disposal is not a cure-all for primary glass waste water disposal (the volume of process and auxiliary waste water discharge far exceeds the 42 l/metric ton (10 gal/short ton) maximum that can be accepted by the batch), experimentation within the industry should be encouraged. Batch disposal of cooling tower blowdown for sheet glass manufacturing has been demonstrated and should be applicable at many plants. It is too early, however, to predict universal applicability and each process should be considered on an individual basis.

PLATE GLASS MANUFACTURING

Plate glass manufacturing produces a large volume of waste water, high in suspended solids with lesser concentrations of dissolved solids, BOD, and COD. Waste water sources and characteristics are described in Section V. Plate glass manufacturing is rapidly being replaced by the float process. Float glass is of similar quality, but is less expensive to produce and process waste waters are insignificant compared to the plate process. Only three plate glass plants remain in this country and at least two of these may be closed by 1977.

Owing to the high operating costs and pollution load, no new plate glass facilities are anticipated. The industry trend of replacing plate glass with float glass has shown that plate glass manufacturing can be successfully eliminated, therefore, only treatment technologies for reducing pollutant loadings from existing plate glass plants will be discussed.

In-Plant Modifications

No apparent in-plant modifications of pollutional significance have been developed for the plate glass manufacturing process. The three remaining plants are relatively modern by plate standards. Plate glass technology development ended with the advent of the float process. Sand and rouge recovery systems are based on the latest technology.

In one case, cerium oxide rather than iron oxide is used as the polishing medium. This plant also has the most efficient waste water treatment of all of the plate glass plants indicating the possible beneficial effects of cerium oxide. Cerium oxide has a higher specific gravity than rouge which may account for better settlability. The switch from rouge to cerium oxide was made for reasons other than pollution control and comparative effluent data before and after the change do not exist. Although insufficient information is available to conclude that cerium oxide is more easily removed from plate waste water, this method might be considered where problems are experienced with iron oxide removal.

Existing Treatment Systems (Alternative A)

Each of the three remaining plate glass plants use lagoon treatment with polyelectrolyte added to the influent waste water. The typical flow rate is 45,900 l/metric ton (11,000 gal/short ton) or 18,168 cu m/day (4.8 mgd) and the suspended solids loading is 690 kg/metric ton (1,375 lb/short ton) or 15,000 mg/l. A cationic polyelectrolyte is added to the influent sewer with mixing accomplished through the natural turbulance of the water. The typical lagoon is square, has an area of approximately 5.26 ha (13 acres) and a working depth of 2.44 m (8 feet).

Available data indicate the highest efficiency presently available using this system is 99.6% suspended solids reduction to produce an effluent concentration of 2.5 kg/metric ton (5 lb/short ton) or 54 mg/l. The COD is reduced approximately 90% to 0.45 kg/metric ton (0.9 lb/short ton) or 10 mg/l. Additional treatment methods can be employed to further reduce effluent suspended solids levels.

Additional Treatment Methods

Several methods for upgrading existing plate glass lagoon systems to increase suspended solids removal efficiency are apparent. Improved polyelectrolyte addition and a two-stage lagoon system should reduce suspended solids to 30 mg/l. An additional reduction to less than 5 mg/l can be accomplished by sand filtration of the lagoon effluent. The filter volume can in turn be reduced by recycling the lagoon effluent back to the grinding and polishing process. These methods of treatment are illustrated in Figure 11.

Lagoon Improvements (Alternative B)-

It should be possible to reduce lagoon effluent suspended solids to 30 mg/l or 1.38 kg/metric ton (2.75 lb/short ton) by improving coagulant mixing and using a two-stage lagoon system. The maximum daily discharge from this system will be 60 mg/l or 2.76 kg/metric ton (5.5 lb/short ton). A mixing tank is added at the lagoon influent to assure proper polyelectrolyte dispersion. The mixing is for one minute or less and is of sufficient velocity that essentially instantaneous mixing of the polyelectrolyte is assured.

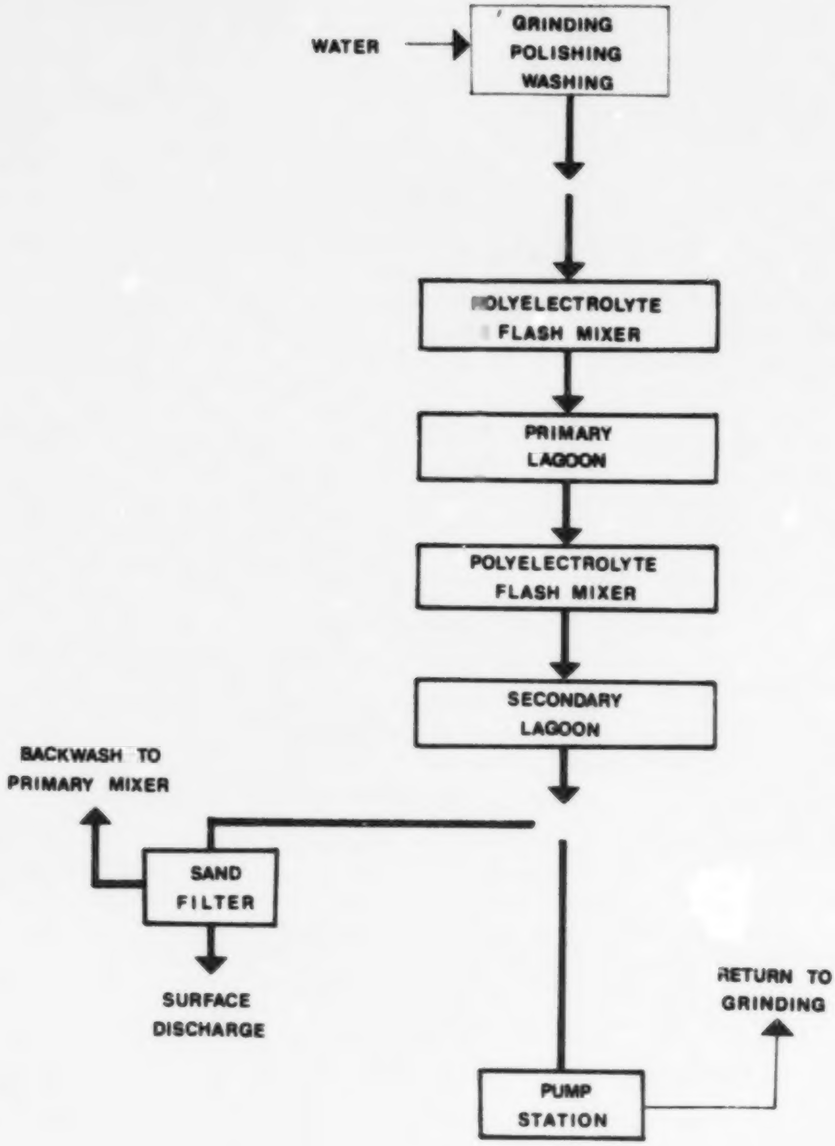
WATER
GRINDING
POLISHING
WASHING
POLYELECTROLYTE
FLASH MIXER
PRIMARY
LAGOON
POLYELECTROLYTE
FLASH MIXER
SECONDARY
LAGOON
BACKWASH TO
PRIMARY MIXER
SAND
FILTER
SURFACE
DISCHARGE
RETURN TO
GRINDING
PUMP
STATION

FIGURE 11
WASTEWATER TREATMENT
PLATE PROCESS

The lagoon is divided into two stages by constructing an additional levee. This will produce two lagoons of 2.43 ha (6 acres) each in the typical plant. The two-stage system will reduce the effects of wind action which is a major cause of low effluent quality. A second mixing tank with provision for adding additional polyelectrolyte between the lagoon segments is provided. It is not certain that the second polyelectrolyte addition step will be necessary, but the equipment is included for cost estimating purposes.

The minimum allowable lagoon surface area and detention time is not known. The data from existing one-cell lagoon systems indicate no correlation between surface area or detention time and suspended solids removal. This may be due to poor design, lack of solids removal, or other factors. The lowest effluent concentration was produced in the lagoon with the shortest detention time. This lagoon was used as the basis for the recommended improvements. The other lagoon systems, having a longer detention time, if properly operated, should have no trouble achieving the same effluent levels.

Many polyelectrolytes are on the market, but laboratory testing is required to determine the most efficient one for each application. Based on current practice in glass plants, a liquid cationic polyelectrolyte is most effective, although some inorganic coagulants may also be effective. The latter should be avoided, if possible, where recycle is considered because of the dissolved solids increase.

Coagulation and sedimentation are widely employed for both water and waste water treatment. An effluent concentration much less than 30 mg/l suspended solids is achieved in many systems. Although most conventional systems are operated in specially designed tanks, there is no evidence to indicate that a lagoon system with sufficient protection against short circuiting and wind cannot achieve an average effluent of 30 mg/l suspended solids.

Filtration (Alternative C)-

Lagoon effluent suspended solids can be further reduced to less than 0.23 kg/metric ton (0.46 lb/short ton) or 5 mg/l by rapid sand filtration. The entire lagoon effluent is filtered through a standard gravity sand filter at an assumed 163 l/min/sq m (4 gpm/sq ft). The filter backwash is recycled to the head of the lagoon for suspended solids removal.

Rapid sand filtration is a widely used and thoroughly proven technology. Such filters are used extensively in water treatment plants following coagulation and sedimentation. Suspended solids levels substantially below 5 mg/l are almost the rule in the water treatment industry and similar values have also been achieved for the filtration of secondary sewage effluent. Other filters such as mixed media, pressure, and upflow filters are also available and may be more desirable in some cases, but rapid sand filters are chosen for illustrative purposes because more background information on cost and treatment efficiency is available.

Filtration and Recycle (Alternative D)-

The volume of water requiring filtration can be substantially reduced by recycling the lagoon effluent back to the grinding process. Recycle is not presently employed in the industry, but there is adequate reason to believe that it is feasible especially if lagoon effluent suspended solids are reduced to 30 mg/l. In most cases, this is a lower concentration than the raw river water presently being used.

A liberal 20% blowdown from the recycle system is assumed to allow for any unforeseen dissolved solids problems. It is likely that a lower blowdown rate can and will be achieved to reduce filtration requirements. The filtered effluent suspended solids concentration will still be 5 mg/l or less but, owing to the 80% volume reduction, the effluent loading will be reduced to 0.045 kg/metric ton (0.09 lb/ short ton). COD will be reduced to 0.09 kg/metric ton (0.18 lb/short ton).

FLOAT GLASS MANUFACTURING

Float glass manufacturing is rapidly replacing the plate glass process as the method for producing high quality thick glass sheets. Conversion to the float process has drastically reduced pollution loadings related to the manufacture of this type of glass. Washing is required for some types of glass and this is the only process waste water resulting from float glass production. Raw waste suspended solids loadings are reduced from 690 kg/metric ton (1,375 lb/short ton) for plate glass to 2 g/metric ton (0.0041 lb/short ton) for float glass. The waste water loading for other parameters is equal to or less than that for suspended solids. More detailed information on waste water characteristics is presented in Section V. The typical flow is only 138 l/metric ton (33 gal/short ton) or 136 cu m/day (0.036 mgd). Owing to the high quality, float washwater is presently not treated.

In-Plant Modifications

Until several years ago, detergents were used in the float washer. In an effort to reduce phosphorus discharge and prevent foaming in the receiving body of water, most plants have now found that sufficient washing can be accomplished without detergents. Non-detergent washing is now typical. There is no evidence to indicate that elimination of detergents in the float wash is detrimental to the product or the process. Elimination of detergents in the float wash is believed possible in all cases.

Recycling washer systems are typical for the industry. Recycling, although having no effect on the quantity of pollutants discharged, does conserve water and should be encouraged. A typical system involves one or two stages of city water washing and a final, totally recycled deionized water rinse. Dissolved solids are removed in the first washer stages and any residual that might cause spotting is removed by the deionized water rinse. Deionizer regeneration requirements are governed by the buildup of dissolved solids in the preceding wash. The more dissolved solids carried over into the final rinse, the more picked up and thus removed by the deionizer.

Recycle and Treatment Methods

Waste water phosphorus loadings can be eliminated by discontinuing the detergent wash. Oil and suspended solids loadings can be reduced by diatomaceous earth filtration. Further reduction of these pollutants may be accomplished by recycling the wash water to other processes. Complete elimination of the discharge of process waste water pollutants is highly theoretical. Evaporation to dryness of waste waters poses both severe economical and environmental problems. A discussion of the treatment technologies to achieve these pollutant reductions is included below and illustrated in Figure 12.

Detergent Elimination (Alternative A) -

The use of detergents for float glass washing can be eliminated without any adverse effects on the manufacturing process as discussed above. Although this is an in-plant modification, by reducing phosphorus, it has the same effect as treatment and is considered as such for the sake of continuity in this report. Elimination of detergent essentially eliminates phosphorus from float process waste water as no other source is known. No data is available on the quantity of phosphorus presently discharged, but elimination of detergents will achieve essentially 100% removal. With credit given for evaporation, trace phosphorus, and analytical error, a typical plant can achieve an effluent phosphorus concentration of 0.05 g/metric ton (0.0001 lb/short ton) or 0.5 mg/l.

Filtration (Alternative B) -

A further decrease in suspended solids and oil can be achieved by filtering the wash water through a diatomaceous earth filter with a media especially treated for oil removal. This type of filter is commonly used to remove oil from boiler condensate. In the glass container industry, a diatomaceous earth filter is being used at one plant to remove machine oil, and emulsified cutting oils similar to those used in the flat glass industry.

The diatomaceous earth filtration system will consist of the filter, precoat tank, and a slurry tank for continuously feeding diatomaceous earth. The filter will be of the dry discharge type so that the sludge will not require dewatering. Sufficient units will be provided to function with one unit down for cleaning or maintenance. Experimentation on flat glass wash water will be required to develop exact design parameters, but the approximate filter rate will be 20.4 to 40.7 l/min/sq m (0.5 to 1 gpm/sq ft) and approximately 0.9 kg(2 lb) of diatomaceous earth is required per 0.45 kg (1 lb) of oil removed.

Effluent oil and suspended solids should be reduced to well below 5 mg/l by diatomaceous earth filtration. These loadings expressed in terms of typical plant production are as follows:

Suspended Solids	0.70 g/kkg	(0.0014 lb/short ton)
Oil	0.70 g.kkg	(0.0014 lb/short ton)

Recycle to Batch and Cooling Tower (Alternative B)-

Float glass washwater, where no detergents are used and after filtration, is of high quality. There exists the possibility that this water can then be recycled as batch water or cooling tower make-up in some plants. The data indicate very low increases of all contaminants result from washing. The dissolved solids will average 300 to 400 mg/l and the concentration of other constituents will be less than 5 mg/l. The exact temperature is not known, but in one case was measured at 37°C (98°F). With the exception of temperature, these characteristics are not significantly different from those of the city water presently being used in the batch or as cooling tower makeup.

Washwater can be collected and pumped through overhead piping to the batch house or cooling tower. The maximum flow acceptable for the batch is 42 l/metric ton (10 gal/short ton). The remaining 96 l/metric ton (23 gal/short ton) may be pumped to the cooling tower. These methods would reduce, but not eliminate, the discharge of pollutants from the float process. Waste water recycled to the cooling tower would eventually be discharged to the environment via the blow-down. The real benefit of this disposal method is in water conservation.

Disposal to the batch would result in a 33% reduction in waste water pollutants. This method has not been demonstrated but owing to the high quality of this waste water, there are no apparent reasons why this disposal method should not be investigated. In some cases batch disposal may be precluded if liquid caustic is used. When soda ash is in short supply, liquid caustic is substituted. It then supplies all the water that can possibly be added to the batch.

Total Recycle (Alternative D)-

It is theoretically possible to recycle the washwater back to the washer following dissolved solids removal. Three dissolved solids removal systems are sufficiently developed at present to

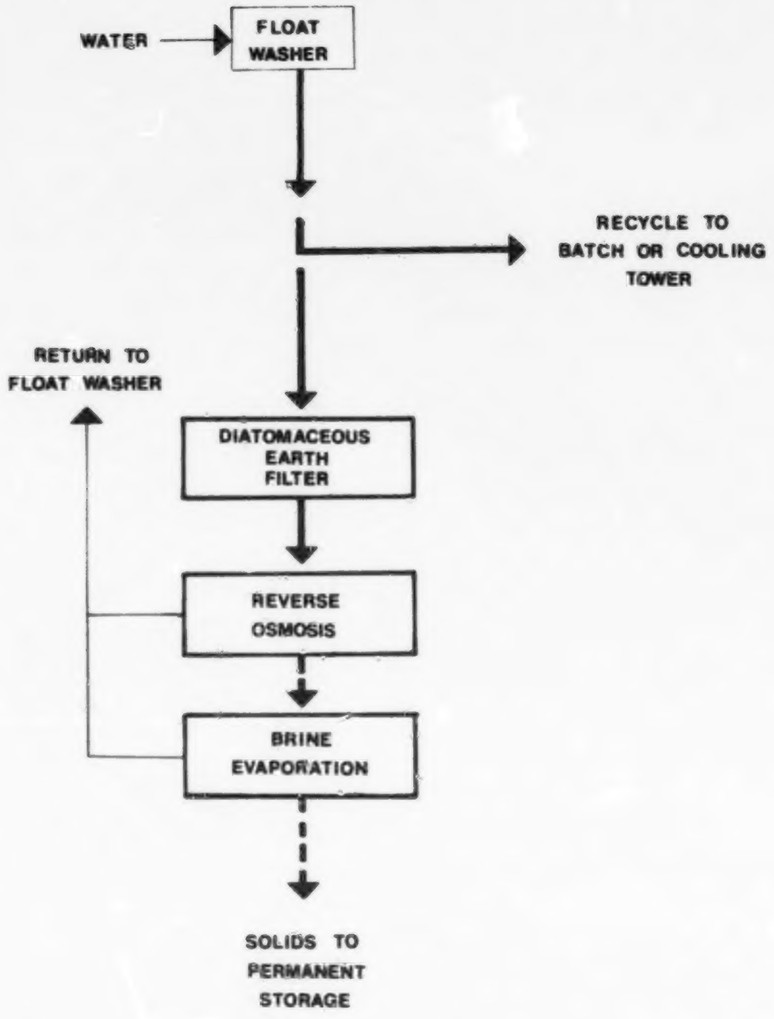
WATER
FLOAT WASHER
RECYCLE TO BATCH OR COOLING TOWER
RETURN TO FLOAT WASHER
DIATOMACEOUS EARTH FILTER
REVERSE OSMOSIS
BRINE EVAPORATION
SOLIDS TO PERMANENT STORAGE

FIGURE 12

WASTEWATER TREATMENT

FLOAT PROCESS

be considered currently available. These are ion exchange, electrodialysis, and reverse osmosis. Ion exchange is already used extensively for final rinse water treatment; however, this process significantly increases the total dissolved solids loadings when regeneration wastes are considered. Current research and development effort in dissolved solids removal technology center on reverse osmosis. Significant improvement and future development of this process are anticipated. For these reasons, reverse osmosis is selected for dissolved solids removal in this report.

It is assumed that reverse osmosis will concentrate the dissolved solids approximately five times and produce a waste water flow rate of 20% of the initial volume treated. This waste water stream must be disposed of if any net pollution reduction is to be achieved. It may be possible to discharge this waste water to the batch, but this has not been demonstrated. The proven method of evaporation to dryness will be assumed in this report.

A complete recycle system using reverse osmosis might be set up as follows. The washwater discharge will first pass through a diatomaceous earth filter with an oil absorptive media to reduce both oil and suspended solids to less than 5 mg/l. Both of these constituents have an adverse effect on the reverse osmosis membranes. The filter is a dry discharge type, and spent diatomaceous earth is discharged at approximately 15% dry solids content, suitable for land disposal. Following filtration, dissolved solids are removed by reverse osmosis. The water is forced at high pressure through a semipermeable membrane that retains most of the dissolved ions. Product water is returned to the washer and the waste brine is evaporated. The steam is condensed and also returned to the washer and the salt residue must be stored permanently in lined basins to prevent ground water contamination.

No total recycle systems have been demonstrated or contemplated in the flat glass industry. At the present time, reverse osmosis is used mainly for boiler water treatment, generally in competition with ion exchange. With the present state of the art, it is impossible to accurately predict the feasibility of the system without pilot plant data. Even if technically feasible, the cost/ benefit ratio will be high. Capital and operating costs are high, relatively large amounts of energy are required, and two types of solid waste must be disposed of on land. The untreated washwater contains only 300-400 mg/l dissolved solids and less than 15 mg/l of other constituents. In most cases these concentrations will not significantly affect the receiving stream.

SOLID TEMPERED AUTOMOTIVE GLASS FABRICATION

Solid tempered automotive glass fabrication produces a waste water with significant quantities of suspended solids, and lesser quantities of oil and BOD. The BOD is the result of oil contamination. Typical raw waste water characteristics are:

Suspended Solids	100 mg/l
Oil	13 mg/l
BOD	15 mg/l

These and other waste water characteristics are more fully described in Section V. The typical flow rate is 49 l/sq m (1200 gal/1000 sq ft). None of the plants studied presently treat solid tempered automotive waste water.

In-Plant Modifications

In-plant modifications may reduce waste water volume and loading. Most plants presently collect the sludge removed from the coolant recycle system for disposal as landfill; however, in a few cases this is discharged to the sewer system imparting an unnecessary load on the treatment system. The method of collection and dewatering used by most plants is a chain-driven scraper system which scrapes the sediment to discharge at one end of the tank and skims the floating material for discharge at the other end. The combined sludge is collected in a portable container for hauling to landfill. The sludge has an approximate moisture content of 90% and is well suited for land disposal.

In some plants, cooling water is sprayed directly onto the glass. Although little contamination is picked up in this quenching process, the water is in contact with the glass and is, therefore, a process waste water. Quenching may be replaced by air cooling thereby reducing the volume of waste water requiring treatment.

Waste water volumes, but not the quantity of pollutants discharged, can be reduced by using recycling washers. Generally older washers tend to be of the once-through type, while new equipment is generally recycling with a two-stage system most common. Water is pumped over the glass from two separate reservoirs, and make-up water is added to the second wash tank. Overflow from second tank goes to the first wash tank and overflow from this tank is discharged to the sewer.

Sufficient water pressure and volume is required for the washer sprays to dislodge and flush away glass particles, oil, or dirt that might be on the glass. Recycling does not significantly affect these requirements until the concentration of contaminants increases to the point where residue is left on the glass. Some recycling can be employed in all plants, even where dissolved solids are high. Only one recycle will cut the waste water flow to half that required for a once-through system.

The extent of recycle is limited by oil and suspended solids buildup. It is theoretically possible to remove these contaminants using a diatomaceous earth filter with oil absorption media. This type equipment is discussed below in more detail. Complete recycle is limited by dissolved solids buildup, with at least one company believing that 300-400 mg/l is the allowable maximum concentration.

Treatment Methods

The major contaminants to be removed from solid tempered automotive glass are suspended solids and oil. Treatment may be accomplished at the individual washer or at end of pipe. It may be beneficial to consider individual treatment for new sources, but owing to limited floor space, end of pipe treatment is most practical for existing plants. Location of the treatment system does not influence the degree of pollutant reduction.

Coagulation-sedimentation and filtration are common methods for reducing suspended solids and oil that are applicable to solid tempered waste water. These treatment methods and a recycle system using reverse osmosis will be discussed and are illustrated in Figure 13. For cost estimating pruposes, no waste water treatment is considered to be treatment Alternative A.

Coagulation Sedimentation (Alternative B)-

Coagulation and sedimentation is commonly used in the water industry for suspended solids removal. Solid tempered automotive glass waste water is not unlike some of the river water commonly treated except for the higher oil content. It should be possible, using a properly designed system and the correct coagulant to achieve an effluent suspended solids concentration of 25 mg/l.

A solids contact coagulation-sedimentation system with sludge dewatering by centrifugation is assumed. Solids contact differs from conventional coagulation-sedimentation in that a portion of the sludge is returned to provide more surface area for trapping the newly coagulated particles. Numerous organic and inorganic flocculants and flocculant aids are available and individual testing will be required in each case to determine the optimum chemicals and addition rate. Polyelectrolytes are preferable to inorganic flocculants because they do not contribute dissolved solids. Owing to the nature of the waste water, however, it is likely that an inorganic flocculant such as alum or a coagulant aid such as bentonite clay will be required. Design parameters cannot be accurately predicted without at least laboratory scale studies. Conventional design rates can be assumed.

Sludge will be dewatered by centrifugation. It is difficult to accurately predict the sludge volume or moisture content without experimental data. A conservative estimate of the volume expressed in terms of production is 21 cu cm/sq m (0.07 cu ft/1000 sq ft) with an 80% moisture content. Sufficient capacity for all equipment will be required so that effluent quality is maintained when portions of the equipment are down for maintenance.

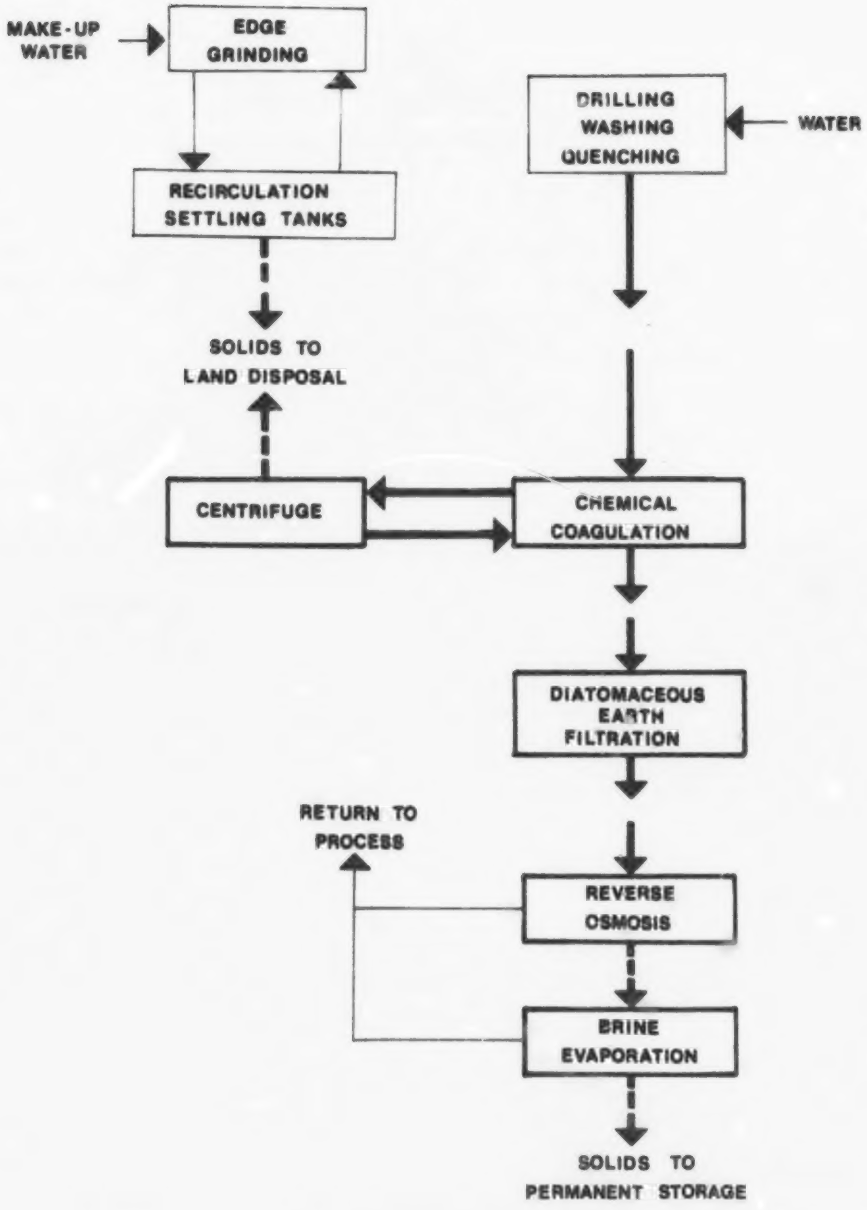
MAKE-UP WATER
EDGE GRINDING
DRILLING WASHING QUENCHING
WATER
RECIRCULATION SETTLING TANKS
SOLIDS TO LAND DISPOSAL
CENTRIFUGE
CHEMICAL COAGULATION
DIATOMACEOUS EARTH FILTRATION
RETURN TO PROCESS
REVERSE OSMOSIS
BRINE EVAPORATION
SOLIDS TO PERMANENT STORAGE

FIGURE 13
WASTEWATER TREATMENT
SOLID TEMPERED AUTOMOTIVE GLASS FABRICATION

Coagulation-sedimentation for suspended solids removal is a well-established process that can be successfully applied to solid tempered automotive glass waste water. An effluent of 25 mg/l suspended solids or 1.22 g/sq m (0.25 lb/1000 sq ft) should be readily achieved and the maximum daily concentration should not exceed 40 mg/l or 1.95 g/sq m (0.4 lb/1000 sq ft). It is likely that oil and, therefore, BOD will also be removed, especially if inorganic coagulants are used, but lacking substantiating evidence, no credit is given for oil and BOD removal. Dissolved solids will be increased somewhat if inorganic coagulants are used.

Filtration (Alternative C)-

A further decrease in suspended solids and oil can be achieved by filtering the settled effluent through a diatomaceous earth filter with a media especially treated for oil removal. This type of filter is commonly used to remove oil from boiler condensate.

The diatomaceous earth filtration system will consist of the filter, precoat tank, and a slurry tank for continuously feeding diatomaceous earth. The filter will be of the dry discharge type so that the sludge will not require dewatering. Sufficient units will be provided so that the system will continue to function with one unit down for cleaning or maintenance. Experimentation on solid tempered automotive waste water will be required to develop exact design parameters, but the approximate filter rate will be 20.4 to 40.7 l/min/sq m (0.5 to 1 gpm/sq ft) and approximately 0.9 kg (2 lb) of diatomaceous earth is required per 0.45 kg (1 lb) of oil removed. Oil, rather than suspended solids, is expected to be limiting; therefore, approximately 1.28 g/sq m (0.26 lb/1000 sq ft) of diatomaceous earth will be required.

Effluent oil and suspended solids should be reduced to well below 5 mg/l by diatomaceous earth filtration. The BOD reduction resulting from oil removal can only be estimated. An effluent BOD of 10 mg/l is assumed although actual values will probably be lower. These loadings expressed in terms of typical plant production are as follows:

Suspended Solids	0.24 g/sq m	(0.05 lb/1000 sq ft)
Oil	0.24 g/sq m	(0.05 lb/1000 sq ft)
BOD	0.49 g/sq m	(0.10 lb/1000 sq ft)

COD will probably be reduced in equal or greater proportion than BOD.

Equivalent effluent levels can also be achieved using sand filtration, as described for plate glass (waste water treatment), if sufficient oil is removed in the coagulation-sedimentation process. Inorganic coagulants such as alum will absorb oil. Trace quantities of oil are commonly removed by coagulation-sedimentation in water treatment plants. The quantity of oil removed and the conditions for removal cannot be accurately stated without experimental data. Another consideration is oil fouling of the sand media. Oil will tend to coat the sand particles, and if sufficient quantities reach the filter, special cleaning procedures may be required. Due to the unknown factors related to sand filtration, a diatomaceous earth filtration system is used for cost estimating.

Total Recycle (Alternative D)-

As in all cases for the flat glass industry, it is theoretically possible to completely recycle the treated effluent following dissolved solids removal. No such system is presently employed in the industry and only very general assumptions on the type of equipment required and the treatment efficiency can be made.

Filtered effluent can be passed through a reverse osmosis unit with 80% of the flow returned to the plant. The other 20%, consisting of waste brine, is evaporated with the steam condensed and returned to the plant and the salt permanently stored in a lined lagoon. The reverse osmosis system is similar for all flat glass applications and is discussed more fully in the float glass treatment section.

Dissolved solids data from the automotive glass tempering subcategory is limited and difficult to interpret because high dissolved solids from auxiliary waste streams are included. The maximum allowable dissolved solids concentration is also unknown. It is certain, however, that maximum possible recycle will be practiced prior to reverse osmosis. For cost estimating purposes,a conservative estimate of half of the typical flow or 24.4 l/sq m (600 gal/1000 sq ft) will be assumed to be treated by reverse osmosis.

Only limited benefit, in terms of pollution reduction, will be achieved by going to a complete recycle system. Parameters other than dissolved solids have essentially been eliminated by prior treatment. Available data indicate a 100 mg/l or 4.9 g/sq m (1 lb/1000 sq ft) dissolved solids increase at present water usage, which may be considered insignificant. Relatively large capital, operating, and power costs are required for reverse osmosis and and an expensive landfill is needed for salt storage.

WINDSHIELD FABRICATION

Oil is the major contaminant to be removed from windshield lamination waste water. The oil contributes to a high organic loading as measured by COD. Lesser quantities of suspended solids and phosphorus are contributed as a result of seaming and detergent washing. Typical concentrations of these parameters are as follows:

Oil	1700 mg/l

COD	1700 mg/l
Suspended Solids	25 mg/l
Phosphorus	5.6 mg/l

The typical flow rate is 175 l/sq m (4300 gal/1000 sq ft). More detailed information on raw waste water characteristics may be found in Section V.

A combination of in-plant modification and end-of-pipe treatment will most efficiently reduce pollutant concentrations. Oil and phosphorus concentrations can be significantly reduced by modifying washing techniques. Residual oil and suspended solids can be reduced by filtration. An alternate to much of the oil removal equipment is the use of air autoclaves. In theory, zero discharge can be accomplished by using reverse osmosis for dissolved solids removal.

In-Plant Modification

In-plant modifications can significantly contribute to a reduction of waste water volume and to the quantity of oil and phosphorus discharged.

Reduction of waste water volume through recycling and reuse, though not reducing the quantity of pollutants discharged, will reduce the size of required treatment units. Windshield fabrication waste water is almost entirely the result of washing operations. Three or four washes are required, depending on the production process, but the number of washes does not significantly affect waste water volume. Of much greater significance is the extent of washwater recycle. The same general considerations govern windshield washwater recycle as govern solid tempered washwater recycle. Older washers tend to be of the once-through type and some type of recycling is generally provided on new equipment. The typical plant employs some recycling, but water usage has not been minimized. Recycle is limited by factors, such as the manufacturing process and background dissolved solids concentration, that vary from plant to plant and cannot be generalized. It is probable that maximum recycle will be practiced wherever possible to minimize treatment costs.

As described in Section V, it is now typical in the industry to use an initial hot water rinse in the post lamination wash to reduce detergent usage and to eliminate the large volume of emulsified oil that is produced when an initial detergent wash is used. This practice should become standard and is assumed as part of all treatment methods.

The limited available data on effluent phosphorus concentrations show increases from near zero to 0.98 g/sq m (0.2 lb/1000 sq ft) indicating significant variation in detergent usage. Insufficient information was available to define the reasons for variable detergent usage, but it is apparent that some plants are producing acceptable windshields with much lower phosphorus discharges than others. Two exemplary plants are discharging less than 0.2 g/sq m (0.04 lb/1000 sq ft) and, therefore, it can be assumed that other plants can develop the technology to reduce phosphorus to this level.

Another method for reducing oil contamination to trace levels is to use air rather than oil autoclaves. Air autoclaves are now used for windshield lamination by several small manufacturers, but are not typical of the industry. Greater handling problems and apparently more manpower are required for air autoclaves. It was impossible to obtain the background data necessary to determine the relative cost of the two systems. However, one company has indicated that its analysis has shown a trade off for new plants between the cost of extra handling using air autoclaves and treatment requirements using oil autoclaves. It is possible to reduce oil to trace levels by using diatomaceous earth filtration as indicated below.

Replacement of existing oil autoclaves would be expensive in terms of the investment required and the loss of production during the change over. It is likely, however, that owing to the reduction in water usage and elimination of a potential pollution problem, air autoclaves will be installed in new plants.

Treatment Methods

Primary methods of windshield fabrication washwater treatment involve removal of the oil from post-lamination washwater. Most of the oil can be removed by centrifugation, plain flotation in an American Petroleum Institute (API) separator, or dissolved air flotation. Suspended solids and residual oil can be removed by oil absorptive media filtration. In theory, it is possible to go to complete recycle by removing dissolved solids. The progression of treatment methods is illustrated in Figure 14. Phosphorus concentrations will be lowered by reducing detergent usage as indicated above. An initial hot water rinse is assumed for all treatment methods. For cost estimating purposes, no waste water treatment is considered to be treatment Alternative A.

Lamination Washwater Treatment - (Alternative B) -

When an initial hot water rinse is used, the oil removed collects in the initial wash reservoir. The oil is not emulsified since no detergents are used and can readily be removed by gravity separation. A cream separator type centrifuge is used for oil removal at one exemplary plant and this method is the most efficient and economical of those observed.

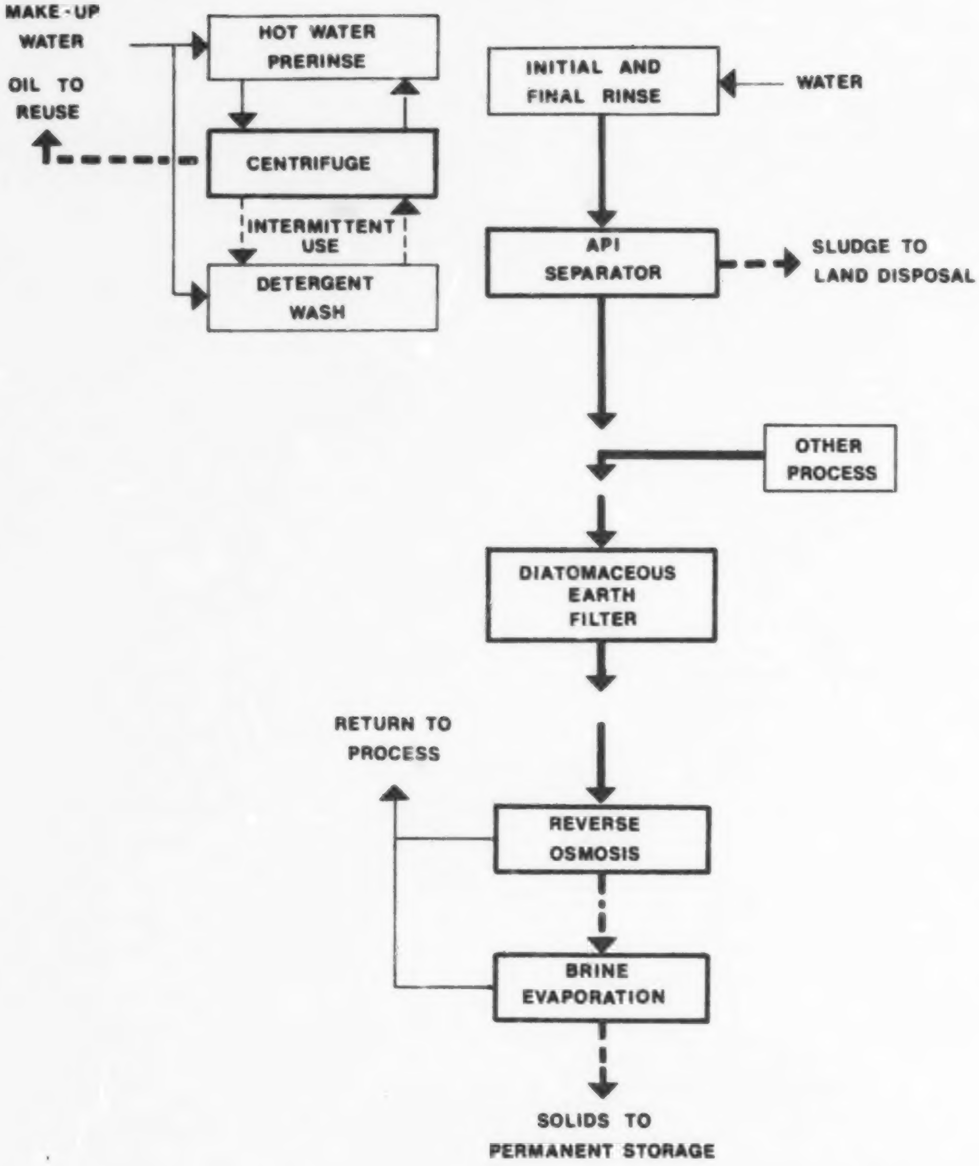
MAKE-UP WATER
HOT WATER PRERINSE
OIL TO REUSE
CENTRIFUGE
INTERMITTENT USE
DETERGENT WASH
INITIAL AND FINAL RINSE
WATER
API SEPARATOR
SLUDGE TO LAND DISPOSAL
OTHER PROCESS
DIATOMACEOUS EARTH FILTER
RETURN TO PROCESS
REVERSE OSMOSIS
BRINE EVAPORATION
SOLIDS TO PERMANENT STORAGE

FIGURE 14
WASTEWATER TREATMENT
WINDSHIELD FABRICATION

Oil and water are drawn from the surface of the hot water rinse reservoir and passed through a centrifuge commonly used in the dairy industry for cream separation. Concentrations of up to 50% oil are reduced to less than 50 mg/l. The oil is sufficiently free of water to be returned to the autoclaves and the water is returned to the hot water rinse reservoir. A cartridge filter is used prior to the centrifuge to minimize cleanouts due to solids build-up, but this feature is optional as the suspended solids content is low.

Sufficient oil is removed so that the only blowdown from the initial hot water rinse is the residual carried over on the glass. So little oil reaches the second stage detergent wash that carry-over on the glass is also the only blowdown or loss from the detergent wash. As a result, the only waste water from this exemplary post-lamination washer is blowdown from the third-stage recycle rinse tank and once-through final rinse water. The rinse water passes through an API separator, but little removal takes place in this unit. An API separator is a good safety feature, however, for trapping any oil that might accidently be discharged and will be included in cost estimates for this system. Oil and COD levels, for the typical total plant effluent, can be reduced to 1.76 g/sq m (0.36 lb/1000 sq ft) and 4.9 g/sq m (1 lb/1000 sq ft), respectively, or a reduction of over 98% in both cases. No credit is taken for phosphorus and suspended solids removal with this system. Similar effluent quality can be obtained by treating with dissolved air flotation although at higher cost because more sophisticated equipment and chemicals are required. With this system, presently in operation at another exemplary plant, oil is not removed at the initial hot water rinse tank, but blowdown from this and all the wash and rinse tanks is collected and treated by dissolved air flotation. Free oil is removed by belt skimmers prior to the flotation unit.

The raw waste water is treated with polyelectrolyte to break any emulsion and combined with a portion of the treated effluent that has been pressurized and saturated with air. This mixture is discharged into the flotation cell. When the pressure is released, small bubbles are formed which cause the oil to float. A disadvantage of this system is that both skimmings and sediment are produced. These are not suitable for reuse and are disposed of as landfill. No information is available on the characteristics of this sludge.

A continuously recycling initial hot water rinse with oil removal has been successfully demonstrated. This system or the alternate dissolved air flotation system can be implemented throughout the industry. The equipment is readily available and can be installed on existing equipment without any interruption of normal operations. Cost estimates in Section VIII are based on the centrifuge system.

Filtration (Alternative C) -

Residual oil and suspended solids can be reduced to trace quantities by filtration in either of two systems that are available. The entire windshield fabrication waste water stream may be filtered through oil absorptive diatomaceous earth or only the laminating washwater may be filtered through oil absorptive diatomaceous earth and the total waste water stream filtered through sand or an equivalent media. The diatomaceous earth filters are the same type discussed for solid tempered automotive glass treatment and flat glass. Sand filters are discussed in the section on plate glass treatment.

More process steps are required for sand filters because the filter backwash must be dewatered. It is assumed that the backwash would be treated by batch coagulation-sedimentation and that the resulting sludge would be dewatered by centrifuge. Approximately a 20% solids sludge would be obtained by this method. No additional equipment is required with the diatomaceous earth filters as these discharge a dry cake that is suitable for land disposal. The diatomaceous earth filtration system is somewhat less expensive and is used for cost estimating purposes.

Waste water effluent quality is assumed to be the same for both systems. Oil is reduced at least 50% compared to the above discharge and 99+% compared to the raw waste water for a residual loading of 0.88 g/sq m (0.18 gal/1000 sq ft) or 5 mg/l based on the typical flow rate. Suspended solids is reduced at least 80% compared to the raw waste water for a typical effluent concentration of 5 mg/l and, therefore, has the same residual loading as for oil. The effluent loadings are conservatively estimated because neither system has been demonstrated in the flat glass industry. No credit is taken for COD reduction as most of the residual at this point is assumed to be contributed by the vinyl washwater and not by oil. This technology has been well demonstrated in other industries and also in a few cases in the glass industry. In one plant making glass containers, a diatomaceous earth filter is being used to remove machine oil, and emulsified cutting oils similar to those used in the flat glass industry. Another plant producing windshields has installed a diatomaceous earth filter on its lamination washwater system on a pilot basis.

Total Recycle (Alternative D) -

As with the other subcategories, it is theoretically possible to totally recycle windshield fabrication waste water following reverse osmosis. No system of this type has been demonstrated or anticipated by the industry for windshield fabrication waste water. Many factors are related to the feasibility of a reverse osmosis system and it can only be assumed that such a system is technically feasible for windshield lamination effluent.

The anticipated system is similar to those indicated for float glass and solid tempered automotive glass fabrication. Maximum recycle would be achieved prior to reverse osmosis, but this is assumed to account for only a 33% reduction because significant recycle is already practiced in the windshield fabrication process. The reverse osmosis product water will be recycled to the manufacturing process. Waste brine will be evaporated with the steam returned to the process and the residual salt permanently stored in a lined lagoon.

Capital and operating costs for a dissolved solids removal system will be high and land will be permarently wasted for salt storage. Little benefit in terms of pollution reduction will be achieved because waste water dissolved solids concentrations are low.

SECTION VIII

COST, ENERGY, AND NON-WATER QUALITY ASPECTS

COST AND REDUCTION BENEFITS OF ALTERNATIVE TREATMENT AND CONTROL TECHNOLOGIES

Investment and operating costs for the alternative waste water treatment and control technologies described in Section VII are presented here.

The cost data include the traditional expenditures for equipment purchase, installation, and operation and where necessary, include solid waste disposal. No significant production losses due to the installation of water pollution control equipment are anticipated. The costs are based on a typical plant for subcategories where no treatment is practiced and on an exemplary plant where treatment is employed. In some cases production rates and waste water volume are adjusted to be more representative of the industry subcategory.

Investment costs include all the equipment, excavations, foundations, buildings etc., necessary for the pollution control system. Land costs are not included because the small additional area required is readily available at existing plants. In all cases, the lagoon systems used for plate glass waste water treatment are already in operation and no additional land costs are required.

Costs have been expressed as August 1971 dollars and have been adjusted using the national average Water Quality Office - Sewage Treatment Plant Cost Index. The cost of capital was assumed to be 8% and is based on information collected from several sources including the Federal Reserve Bank. Depreciation is assumed to be 20 year straight line or 5% of the investment cost. Operating costs include labor, material, maintenance, etc., exclusive of power costs. Energy and power costs are listed separately. August 1971 energy costs were assumed to be $.018 per kilowatt-hour for electricity and $1/million BTU for the steam required for brine evaporation.

Six subcategories have been defined in the development document. Costs for each subcategory will be covered separately. The various alternative treatment systems will be discussed and factors that might affect the cost will be indicated. No process waste water results from sheet and rolled glass manufacturing and, therefore, no treatment costs result for these subcategories. Cost for the other subcategories are summarized below.

Plate Glass Manufacturing

The typical plate galss manufacturing plant may be located in any part of the country and is at least 12 years old. Advanced plate

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glass manufacturing technology is used but this has not been improved since the early 1960's when the advantages of the float process became apparent. Annual production at the plant is approximately 150,000 metric tons. Costs and effluent quality for the four treatment alternatives are summarized in Table 10.

Alternative A - Lagoon with Polyelectrolyte Addition

Alternative A is the treatment universally practiced at plate glass plants and includes polyelectrolyte addition to the raw waste water followed by sedimentation in a one cell lagoon.

Costs. No additional cost.

Reduction Benefits. Suspended solids are reduced 99.6% and COD is reduced 90%.

Alternative B - Lagoon Improvements

Alternative B consists of partition of the existing one cell lagoons into two cells in series with polyelectrolyte addition at the entrance to each.

Costs. Incremental investment costs are $57,000 and total annual costs are $32,800 over Alternative A.

Reduction Benefits. The incremental reduction of suspended solids compared to Alternative A is 70%. Total reduction of suspended solids is 99.8%.

Alternative C - Filtration

Alternative C is sand filtration of the lagoon effluent resulting from Alternative B.

Costs. Incremental investment costs are $472,000 and total annual costs are $142,500 over Alternative B.

Reduction Benefits. The incremental reduction of suspended solid compared to Alternative B is 83%. Total reduction of suspended solids is almost 100%.

Alternative D - Filtration and Recycle

Alternative D is recycle of the lagoon effluent resulting from Alternative B to the plate glass grinders and sand filtration of a 20% blow-down prior to dishcarge to the receiving stream. Owing to the lower operating cost for Alternative D, the annual cost for this system is less than for Alternative C.

Costs. Incremental investment costs are $127,000 over Alternative C but total annual costs re $36,800 less than Alternative C.

TABLE 10

WATER EFFLUENT TREATMENT COSTS
FLAT GLASS MANUFACTURING
PLATE GLASS

Alternative Treatment or Control Technologies:	($1,000) A	B	C	D
Investment	0	57.	529.	656.
Annual Costs:				
Capital Costs	0	4.6	42.3	52.5
Depreciation	0	2.9	26.5	32.8
Operating and Maintenance Costs (excluding energy and power costs)	0	22.7	99.7	49.7
Energy and Power Costs	0	2.6	6.8	3.5
Total Annual Cost	0	32.8	175.3	138.5

Effluent Quality:

Effluent Constituents		Raw Waste Load	Resulting Effluent Levels			
Flow	(l/metric ton)	45,900	45,900	45,900	45,900	9,200
Suspended Solids	(kg/metric ton)	690.	2.5	1.38	.23	.045
COD	(kg/metric ton)	4.6	.45	.45	.45	.09
Flow	(l/sec)	210	210	210	210	40
Suspended Solids	(mg/l)	15,000	54	30	5	5
COD	(mg/l)	100	10	10	10	10

Reduction Benefits. Incremental reductions are 80% for suspended solids and COD compared to Alternative C. Total reductions are essentially 100% for suspended solids and 98% for COD.

Three plate glass plants remain in operation in the United States. All of these plants practice Alternative A treatment but none of the other alternatives are practiced at present. There is nc apparent benefit for phasing costs within an alternative. However, where one alternative includes a previous alternative, the earlier alternatives may be built first.

The cost of Alternative B is not expected to vary significantly between plants. The cost of Alternative C and D will vary somewhat depending on the volume of water filtered. A reduction in plant water usage, although theoretically possible, is not practical because extensive in-plant modifications will be required. For this reason, costs are based on the plant having the highest flow rate and will be somewhat less for other plants. Another unknown factor is the amount of blowdown required for the recycle system. A liberal 20% blowdown is assumed. Filtration costs will be reduced if the allowable blowdown can be reduced.

The age of equipment and process employed do not significantly affect costs. No process changes are required and significant engineering or non-water quality environmental impact problems are not anticipated.

Float Glass Manufacturing

The typical float glass manufacturing plant may be located in any part of the country and has been built since 1960. Annual production is approximately 360,00 metric tons. Three alternative methods of treatment are discussed. Costs and effluent quality are summarized in Table 11.

Alternative A - No Waste Water Treatment or Control

Alternative A is the elimination of detergent usage in the float washer. As can be seen, the waste water is of relatively high quality and all plants presently discharge this water untreated.

Costs. None.

Reduction Benefits. Close to 100% phosphorus reduction.

Alternative B - Filtration

Alternative B uses diatomaceous earth filtration for suspended solids and oil removal. These pollutants will be reduced to less

TABLE 11

WATER EFFLUENT TREATMENT COSTS FLAT GLASS MANUFACTURING FLOAT GLASS

Alternative Treatment or Control Technologies:	($1,000)			
	A	B	C	D
Investment	0	50	57	134
Annual Costs:				
Capital Costs	0	4.0	4.6	11
Depreciation	0	2.5	2.9	6.7
Operating and Maintenance Cost (excluding energy and power costs)	0	3.5	5.5	28.4
Energy and Power Costs	0	0.8	0.9	12.5
Total Annual Cost	0	10.8	13.9	58.6

Effluent Quality:

Effluent Constituents		Raw Waste Load	Resulting Effluent Levels			
Flow	(l/metric ton)	138	138	138	92	No Discharge
Suspended Solids	(g/metric ton)	2	2	.7	.4	
Oil	(g/metric ton)	0.7	0.7	.7	.7	
COD	(g/metric ton)	2	2	.2	.2	
Flow	(l/sec)	1.6	1.6	1.6	1.1	
Suspended Solids	(mg/l)	15	15	5	5	
Oil	(mg/l)	5	5	5	5	
COD	(mg/l)	15	15	15	15	

than 5 mg/l. This high quality effluent could be discharged or reused in the float process as discussed in Alternative C or in glass fabrication operations if they are available.

Costs. Incremental investment costs are $50,000 and total annual costs are $10,800 over alternative A.

Reduction Benefits. Suspended solids are reduced 67% over Alternative A. Additional reductions in oil are accomplished.

Alternative C - Recycle to Batch and Cooling Tower

Alternative C includes recycle of filtered float washwater to the batch and cooling tower. Process waste water pollutants are reduced an additional 33% below that achievable by Alternative B. The waste load recycled to the batch will become part of the glass and the waste load recycled to the cooling tower will constitute a portion of the cooling tower blowdown.

Costs. Incremental investment costs are $7,000 and total annual costs are $3,100 over Alternative B.

Reduction Benefits. Reduction of 33% of process waste water discharge over Alternative B.

Alternative D - Total Recycle

Alternative D is the total recycle of waste water back to the process following treatment using diatomaceous earth filtration for suspended solids removal and reverse osmosis for dissolved solids removal. Waste brine is evaporated to dryness and residual salt permanently stored. Sufficient suspended and dissolved solids are removed so that the water can be reused for float washing. No liquid wastes are discharged.

Costs. Incremental investment costs are $127,000 and total annual costs are $55,500 over Alternative A.

Reduction Benefits. Waste water discharge is totally eliminated. Reduction of suspended solids, COD, phosphorus and all other pollutant constituents of 100%.

About half of the float glass plants produce process waste water in the form of washwater. Washing is not required at the other plants and no process waste water is produced. Washing is necessary where practiced and cannot be eliminated on the bases of the information gathered for this study.

No cost is associated with Alternative A. The evidence gathered indicates that detergent can simply be eliminated from the process. The cost of Alternatives C and D will depend upon the quantity of glass produced and the allowable dissolved solids build-up. The typical plant is one of the largest float plants so that the costs should be somewhat conservative with respect to the entire subcategory. The high cost of Alternative D is the result of dissolved solids removal and waste brine disposal. These costs could be only roughly estimated since no system of this type is presently in operation. Each of the alternatives is a separate system and there is no benefit to be derived from cost phasing.

As discussed in the Development Documents the age of equipment and the process employed do not significantly affect costs. No process changes are required and no significant engineering or non-water quality environmental impact problems are anticipated.

Solid Tempered Automotive Glass Fabrication

The typical solid tempered automotive glass fabrication plant may be located in any part of the country and uses process equipment that has been modified within the last 10 to 15 years. Annual production is 3.5 million square meters. Cost and effluent quality for the four treatment alternatives discussed are summarized in Table 12.

Alternative A - No Waste Water Treatment or Control

Alternative A is no waste water treatment or control. The waste water is of relatively high quality except for suspended solids. At the present time, no plants treat solid tempered automotive waste water. Land disposal of coolant sludge is assumed, as this is almost universally practiced in the industry.

Costs. None.

Reduction Benefits. None.

Alternative B - Coagulation-Sedimentation

Alternative B is solids contact coagulation-sedimentation of all process waste water, centrifugation of waste sludge and land dispcsal of dewatered waste solids.

Costs. Incremental investment costs are $81,000 and total annual costs are $24,100 over Alternative A.

Reduction Benefits. Effluent suspended solids are reduced 75%.

Alternative C - Filtration

Alterantive C is oil absorptive diatomaceous earth filtration of the effluent from Alternative B. The spent diatomaceous earth is also disposed of as landfill.

TABLE 12

WATER EFFLUENT TREATMENT COSTS
FLAT GLASS MANUFACTURING
SOLID TEMPERED AUTOMOTIVE GLASS FABRICATION

Alternative Treatment or Control Technologies:	($1,000) A	B	C	D
Investment	0	81.	149.	364.
Annual Costs:				
Capital Costs	0	6.5	11.9	29.1
Depreciation	0	4.1	7.5	18.2
Operating and Maintenance Costs (excluding energy and power costs)	0	11.7	17.9	53.4
Energy and Power Costs	0	1.8	4.8	25.7
Total Annual Cost	0	24.1	42.1	126.4

Effluent Quality:

Effluent Constituents		Raw Waste Load	Resulting Effluent Levels			
Flow	(l/sq m)	49	49	49	49	No Discharge
BOD	(g/sq m)	.73	.73	.73	.49	
Suspended Solids	(g/sq m)	4.9	4.9	1.22	.24	
Oil	(g/sq m)	.64	.64	.64	.24	
Flow	(l/sec)	7.9	7.9	7.9	7.9	No Discharge
BOD	(mg/l)	15	15	15	10	
Suspended Solids	(mg/l)	100	100	25	5	
Oil	(mg/l)	13	13	13	5	

Costs. Incremental investment costs are $68,000 and total annual costs are $18,000 over Alternative B.

Reduction Benefits. Incremental reduction of suspended solids is 80%. Total reductions of suspended solids, oil and BOD are 95, 62, and 33% respectively.

Alternative D - Total Recycle

Alternative D is the further treatment of the effluent from Alternative C using reverse osmosis. The waste brine is evaporated and the residual salt permanently stored. Sufficient suspended and dissolved solids are removed so that the water can be reused in the manufacturing process. No liquid wastes are discharged.

Cost. Incremental investment costs are $215,000 and total annual costs are $84,300 over Alternative C.

Reduction Benefits. Reduction of suspended solids, oil, BOD and all other pollutant constituents of 100%.

The volume of water to be treated depends on the amount of recycling practiced. More extensive recycling at the typical plant is representative of the better plants in this subcategory. A further reduction in water usage may be possible but is not assumed in the cost estimate. For those plants presently using more water than the typical plant, higher cost may be required for increase treatment cost or for in-plant modifications to reduce water usage. The costs recorded here are representative of an above average size plant with moderate water recycling and reuse practices. A flow reduction of 50% prior to the reverse osmosis system in Alternative D is assumed.

None of the treatment methods is presently practiced in the flat glass industry. The technology is transferred from other industries and for this reason the cost estimates may be somewhat rough. This is especially true for the reverse osmosis system in Alternative D, where many unknowns had to be assumed. There is no apparent benefit for phasing costs within an alternative; however, where one alternative includes other alternatives, the earlier alternatives may be built first.

The age of equipment and the process employed do not significantly affect costs. No process changes are required and no significant engineering or non-water quality environmental impact problems are anticipated.

Windshield Fabrication

The typical windshield fabrication plant may be located in any part of the country and uses oil autoclaves. Annual production is 750,000 square meters. Cost and effluent quality for the four treatment alternatives discussed are summarized in Table 13.

TABLE 13

WATER EFFLUENT TREATMENT COSTS
FLAT GLASS MANUFACTURING
WINDSHIELD FABRICATION

Alternative Treatment or Control Technologies	($1,000)			
	A	B	C	D
Investment	0	32.	115.	317.
Annual Costs:				
Capital Costs	0	2.6	9.2	25.4
Depreciation	0	1.6	5.8	15.8
Operating and Maintenance Costs (excluding energy and power costs)	0	8.	13.6	48.5
Energy and Power Costs	0	2.4	4.2	33.1
Total Annual Cost	0	14.6	32.8	122.8

Effluent Quality:

Effluent Constituents		Raw Waste Load	Resulting Effluent Levels			
Flow	(l/sq m)	175	175	175	175	No Discharge
Oil	(g/sq m)	298	298	1.76	.88	
COD	(g/sq m)	298	298	4.9	4.9	
Suspended Solids	(g/sq m)	4.4	4.4	4.4	.88	
Phosphorus	(g/sq m)	.98	.98	.98	.2	

Flow	(l/sec)	6	6	6	6	No Discharge
Oil	(mg/l)	1700	1700	10	5	
COD	(mg/l)	1700	1700	28	28	
Suspended Solids	(mg/l)	25	25	25	5	
Phosphorus	(mg/l)	5.6	5.6	5.6	1	

Alternative A - No Waste Water Treatment or Control

Alternative A is no waste water treatment or control.

Costs. None.

Reduction Benefits. None.

Alternative B - Lamination Washwater Treatment

Alternative B is modification of the post lamination washer sequence to provide a continuously recycling initial hot water rinse, oil removal by centrifugation of the recirculating hot rinse water, recycle of oil back to the process, and treatment of other post lamination rinse waters by gravity oil separation. Other process waters are not treated. Neligible waste solids are produced.

Costs. Incremental investment costs are $32,000 and total annual costs are $14,600 over Alternative A.

Reduction Benefits. Oil is reduced by 99.4% and COD is reduced by 98.4%.

Alternative C - Filtration

Alternative C includes oil absorptive diatomaceous earth filtration of all process waste water in addition to the treatment system discribed for Alternative B. The spent diatomaceous earth is disposed of as landfill. Phosphorus is reduced by more vigorous inplant detergent control and improved washing techniques.

Costs. Incremental investment costs are $83,000 and total annual costs are $18,200 over Alternative B.

Reduction Benefits. Incremental reductions are 50% for oil and 80% for suspended solids. Total reductions are 99.7% for oil, and 80% for suspended solids and phosphorus.

Alternative D - Total Recycle

Alternative D is total recycle and reuse of the water following reverse osmosis treatment for dissolved solids removal. The waste brine is evaporated and the residual salt is permanently stored.

Costs. Incremental investment costs are $202,000 and the total annual costs are $90,000 over Alternative C.

Reduction Benefits. Reduction of oil, COD, suspended solids, phosphorus and all other pollution constituents of 100%.

As with the other subcategories, the volume of water treated and, therefore, the cost of treatment is related to the amount of recycling that can be practiced. Approximately the same absolute l/sq m are required at all plants, but the quantity discharged can be reduced by using recycling washers. Relatively more recycle is presently practiced for windshield fabrication than for other subcategories but it may still be possible by using recycling washers in all cases and by carefully controlling flow to further reduce usage. The typical plant is of less than average size and practices moderate water recycling and reuse. Costs may be as much as 4 times higher for the larger plants because fo the higher water volume. A flow reduction of 33% prior to the reverse osmosis system in Alternative D is assumed.

New plants will probably use air rather than oil autoclaves. This will reduce the waste water flow rate by approximately 23% and eliminate the need for Alternative B treatment.

The technology for Alternatives C and D was transferred from other industries and is presently not practiced in the flat glass industry. The cost estimates for these alternatives may be somewhat rough because of the unknowns involved. This is especially true for the reverse osmosis system in Alternative D. There is no apparent benefit for phasing costs within an alternative; however, where one alternative includes other alternatives, the earlier alternatives may be built first.

It is possible, but not likely that some modification of the washers may be required to effect the detergent reduction indicated for Alternative C. No equipment modification was required at the exemplary plant where this technology is used but it is possible that modification will be required if another type of washer is used. Other considerations such as the age of equipment or the process employed do not significantly affect cost and no significant engineering of non-water quality environmental impact problems are anticipated.

ENERGY REQUIREMENTS OF TREATMENT AND CONTROL TECHNOLOGIES

The energy required to implement in-plant control measures at a typical flat glass plant is 5 kw or less. The energy requirements are almost entirely for pumping to recycle washer water.

The energy requirements of the end-of-pipe treatment technology are relatively low for conventional operations such as coagulation-sedimentation and filtration, but are much higher for total recycle systems incorporating reverse osmosis or evaporation. Typical energy requirements for conventional treatment are 45 kw or less. The energy requirements may run as high as 1000 kw for a total recycle system because of the energy required for evaporation.

No information was provided by the industry relative to the energy requirements of individual manufacturing plants. Large quantities of energy are used in primary glass production to produce the high temperatures required for glass melting and annealing and numerous large horsepower motors are needed for grinding and polishing in the plate process. Less energy is required for automotive glass fabrication. The additional energy required to implement conventional control and treatment technologies is less than 1% of process requirements for primary manufacturing and is estimated to be less than 10% of process requirements for automotive glass fabrication.

NON-WATER QUALITY ASPECTS OF TREATMENT AND CONTROL TECHNOLOGIES

Air Pollution

There are no significant air or noise pollution problems directly associated with the treatment and control technologies. The waste waters and sludges are odorless and no nuisance conditions result from their treatment or handling. Incineration is not used in the treatment technologies so no air pollution is caused by this source. Water vapor resulting from the evaporation of reverse osmosis brines is expected to be relatively pure.

A non-water quality aspect of perhaps greater significance than air pollution is the high energy required for total recycle systems. In view of the limited availability of clean energy sources and the air pollution problems associated with other energy sources, the benefits derived from a total recycle system should also be weighed against the energy required to operate such a system.

Solid Waste Disposal

Landfilling of properly dewatered sludges from the flat glass industry is an appropriate means of disposal. The wastes are largely inorganic and incineration, composting, or pyrolysis would not be effective in reducing their volume. The dewatered solids are relatively dense and they are stable when used as fill material. If disposed of using proper sanitary landfill techniques, solids from flat glass manufacturing should cause no environmental problems.

With the exception of plate glass manufacturing, the volume of sludge associated with the various control and treatment technologies is relatively small. The lagoons used for plate glass suspended solids removal also serve as sludge disposal sites. The levees are generally raised to keep pace with the rising sediment level. At older plate plants large areas of low-lying land have been filled in. In some cases this is reclaimed as park land by spreading topsoil over the dry sludge solids.

Three types of waste solids are produced by the treatment systems indicated for the float, solid tempered automotive, and windshield manufacturing processes. These are (1) coagulation-sedimentation sludges associated with tempering waste waters, and (2) spent diatomaceous earth, and (3) brine residue associated with at least one treatment alternative for each of the subcategories. The coagulation-sedimentation sludge is assumed to be dewatered by centrifuge to about 20% dry solids and the typical volume produced is estimated to be 0.38 cu m/day (13.5 cu ft/day).

Spent diatomaceous earth has an estimated moisture content of 85%, but is dry to the touch. This material is stable and should be suitable for landfill. Estimated production of diatomaceous earth waste is less than 0.23 cu m/day (8 cu ft/day) for each of the subcategories.

The salt residue that will be produced by a total recycle system will present the biggest disposal problem. To prevent ground water contamination, it must be permanently stored in lined basins. Only as much water as will evaporate can be allowed into the basin. The land used for salt storage will be permanently spoiled. The salt residue produced by the tempering and laminating processes is conservatively estimated to be 0.56 cu m/day (20 cu ft/day). Salt storage costs are directly related to the cost of land and the type of lining used.

The cost for hauling the coagulation sludge and diatomaceous earth to landfill, assuming a commercial disposal firm is used, is $60 to $100 a month. Disposal costs are variable depending on the equipment used and distance to the disposal site.

SECTION IX

EFFLUENT REDUCTION ATTAINABLE THROUGH THE APPLICATION OF THE BEST PRACTICABLE CONTROL TECHNOLOGY CURRENTLY AVAILABLE EFFLUENT LIMITATIONS GUIDELINES

INTRODUCTION

The effluent limitations that must be achieved July 1, 1977 are to specify the degree of effluent reduction attainable through the application of the Best Practicable Control Technology Currently Available. Best Practicable Control Technology Currently Available is generally based upon the average of the best existing performance by plants of various sizes, ages, and unit processes within the industrial category or subcategory. This average is not based upon a broad range of plants within the flat glass industry, but based upon performance levels achieved by exemplary plants.

Consideration must also be given to:

a. The total cost of application of technology in relation to the effluent reduction benefits to be achieved from such application;

b. the size and age of equipment and facilities involved;

c. the processes employed;

d. the engineering aspects of the application of various types of control techniques;

e. process changes; and

f. non-water quality environmental impact (including energy requirements).

Also, Best Practicable Control Technology Currently Available emphasizes treatment facilities at the end of a manufacturing process, but also includes the control technologies within the process itself when the latter are considered to be normal practice within an industry.

A further consideration is the degree of economic and engineering reliability which must be established for the technology to be "currently available". As a result of demonstration projects, pilot plants, and general use, there must exist a high degree of confidence in the engineering and economic practicability of the technology at the time of commencement of construction or installation of the control facilities.

EFFLUENT REDUCTION ATTAINABLE THROUGH THE APPLICATION OF BEST PRACTICABLE CONTROL TECHNOLOGY CURRENTLY AVAILABLE

Based on the information contained in Sections III through VIII of this document, a determination has been made of the degree of effluent reduction attainable through the application of the Best Practicable Control Technology Currently Available for the flat glass segment of the glass manufacturing category. The effluent reductions are summarized here.

Suspended Solids

A principal pollutant constituent in waste waters from the manufacture of plate glass and the fabrication of solid tempered automotive glass is suspended solids. Application of this technology will reduce suspended solids levels by 99.8% for plate glass manufacturing and 75% for solid tempered automotive glass fabrication. The low percentage for automotive tempering is an indication of the high quality of the raw waste water.

Suspended solids will not be significantly reduced by the application of this control technology to float glass manufacturing and to windshield fabrication waste waters.

Oil

At least trace amounts of oil are present in all flat glass waste waters with the highest concentration resulting from windshield fabrication. This control technology will reduce oil levels in windshield fabrication waste waters by 99.4%, but will not effect significant oil removal for the other subcategories.

Oxygen Demanding Materials

Oxygen demand in the flat glass industry is related to the oil content of the waste water. COD levels will be reduced 90% in plate glass and 98% in windshield waste waters using this control technology. The BOD or COD for the other subcategories will not be reduced, but the levels are already low by conventional standards.

pH

With the exception of plate glass manufacturing, the pH of the flat glass waste waters falls within the accepted range of 6 to 9. In some cases, raw plate glass waste water may have a pH level above 9, but neutralization is already universally practiced where necessary.

Total Phosphorus

Some phosphorus may be present in float glass and windshield fabrication waste waters as a result of detergent usage. This control technology eliminates detergent usage in the float process, but no treatment or control is applied to windshield fabrication wastewaters.

Temperature

Process waste waters from the float and automotive glass fabrication subcategories may show some temperature increase because of heated washwater requirements. Application of this control technology will not result in significant temperature reduction.

Dissolved Solids

Dissolved solids increase somewhat as a result of all of the glass manufacturing processes. The average typical increase is about 100 mg/l. High dissolved solids in the process water cannot be tolerated because almost all of the water is used for washing and high dissolved solids leave a residue on the glass. For this reason, flat glass process waste water will always be of high quality with respect to dissolved solids. This control technology does not reduce dissolved solids.

IDENTIFICATION OF THE BEST PRACTICABLE CONTROL TECHNOLOGY CURRENTLY AVAILABLE

In-plant control measures as well as end-of-pipe treatment techniques contribute to the best pollution control technology currently available, although emphasis is on end-of-pipe treatment. Water recycle and reuse, although not a significant factor in this technology, will tend to reduce the cost of end-of-pipe treatment facilities.

The Best Pollution Control Technology Currently Available for the subcategories of the flat glass industry is summarized below. Recommended effluent limitations are summarized in Table 14. The limitations are expressed in grams or kilograms of pollutant per metric ton or 1000 square meters of product. These limitations are both daily maximums and monthly averages except where noted.

Sheet Glass Manufacturing

No process waste water results from the sheet glass manufacturing process, therefore, no waste water or waste load should be discharged.

Rolled Glass Manufacturing

No process waste water results from the rolled glass manufacturing process, therefore, no waste water or waste load should be discharged.

Plate Glass Manufacturing

The control technology is partition of existing one-cell lagoons into two cells in series with provision for polyelectrolyte addition at the entrance to each cell. This is to provide more efficient coagulation and to reduce the effects of short circuiting

TABLE 14

RECOMMENDED DAILY AVERAGE EFFLUENT LIMITATIONS USING BEST PRACTICABLE CONTROL TECHNOLOGY CURRENTLY AVAILABLE

	Suspended Solids	Oil	Total Phosphorus	pH
Sheet Glass	No waste water discharge			
Rolled Glass	No waste water discharge			
Plate Glass				
kg/metric ton	2.76(1.38)*	-	-	6-9
lb/short ton	5.52(2.76)*			
Float Glass				
g/metric ton	2.00	1.40	0.05	6-9
lb/short ton	0.004	0.0028	0.0001	
Solid Tempered Automotive Glass				
g/sq m	1.95(1.22)*	0.64	-	6-9
lb/1000 sq ft	0.40(0.25)*	0.13		
Windshields				
g/sq m	4.40	1.76	1.07	6-9
lb/1000 sq ft	0.90	0.36	0.22	

* Figures in parenthesis are monthly average effluent limitations

and wind action on sedimentation. The monthly average effluent limitations for suspended solids are 1.38 kg/metric ton (2.76 lb/short ton); and a pH of between 6.0 and 9.0.

Float Glass Manufacturing

The control technology is elimination of detergent usage from the float washing process. Effluent limitations for suspended solids are 2 g/metric ton (0.0040 lb/short ton); for oil, 1.40 g/metric ton (0.0028 lb/short ton); for total phosphorus, 0.05 g/metric ton (0.0001 lb/short ton, and; pH of between 6.0 and 9.0.

Solid Tempered Automotive Glass Fabrication

The control technology is coagulation-sedimentation of all process waste waters with land disposal of dewatered waste solids. Effluent limitations for suspended solids are 1.22 g/sq m (0.25 lb/1000 sq ft); for oil, 0.64 g/sq m (0.13 lb/1000 sq ft); and a pH of between 6.0 and 9.0.

Windshield Fabrication

The control technology is modification of the post-lamination washer sequence to provide a continuously recycling initial hot water rinse, oil removal by centrifugation of the recirculating hot rinse water, recycle of oil back to the process, and treatment of other postlamination rinse waters by gravity oil separation. Negligible waste solids are produced. Effluent limitations for suspended solids are 4.4 g/sq m (0.9 lb/1000 sq ft); for oil, 1.76 g/sq m (0.36 lb/1000 sq ft); for total phosphorus, 1.07 g/sq m (0.22 lb/1000 sq ft); and a pH of between 6.0 and 9.0.

RATIONALE FOR THE SELECTION OF BEST PRACTICABLE CONTROL TECHNOLOGY CURRENTLY AVAILABLE

Engineering Aspects of Application

In all cases, this control technology has been applied in the glass industry or in another industry where the characteristics of the water treated are sufficiently similar to provide a high degree of confidence that the technology can be transferred to the glass industry.
The derivation and rationale for selection of the control technology are described in detail in Sections V and VII. These may be briefly summarized as follows:

Plate Glass Manufacturing -

Existing treatment of plate glass waste waters is uniformly inadequate and must be upgraded. The recommended lagoon modifications and the resulting effluent limitations are based on company experience and engineering judgement. The recommended effluent concentrations are being achieved part of the time in existing plate glass lagoon systems and there is no evidence to indicate that these levels can not be achieved using the proposed technology.

Float Glass Manufacturing -

Elimination of detergents from the float washer will result in a high quality waste water suitable for discharge without further treatment. The detergent wash has already been eliminated at most plants and there is no evidence to indicate elimination of detergents is detrimental to the product or the manufacturing process. Of the six plants that presently wash float glass, four have already eliminated detergents.

Solid Tempered Automotive Glass Fabrication -

None of the plants studied presently treat solid tempered automotive waste water. Treatment for suspended solids removal is required prior to discharge. The recommended coagulation-sedimentation technology is commonly used for removing suspended solids from both water and waste water. Company experience and engineering judgement indicate that this treatment technology and the resulting effluent limitations can be successfully applied for solid tempered automotive waste water treatment.

Windshield Fabrication -

One plant is presently achieving the recommended effluent limitations using the technology indicated for treating post lamination wash water. It is also possible to achieve the same effluent quality using dissolved air floatation but at higher cost. The equipment for either system is readily available and can be installed on existing washers without any interruption of normal operations.

Total Cost of Application

Based on the information presented in Section VIII of this document, the industry as a whole would have to invest approximately $900,000 to achieve the effluent limitations prescribed herein. The increased annual costs of applying this control technology are approximately $345,000 for the industry.

Size and Age of Equipment

The size of plants within the same subcategory is not sufficiently different to substantiate differences in control technology based on size. All glass plants are continuously modernized so that age of equipment and facilities does not provide a basis for differentiation in the application of this control technology.

Processes Employed

All plants in a given subcategory use very similar manufacturing processes and produce similar waste water discharges. The control technology for a given subcategory is compatible with all of the manufacturing processes presently used in that subcategory.

Process Changes

A minor process change is required in one subcategory for the implementation of this technology. It will be necessary for the plants in the windshield fabrication subcategory that are still using an initial detergent wash as part of the post-lamination washing sequence to eliminate this wash in favor of a recycling hot water rinse. As far as is known, this can be accomplished without any additional equipment by simply eliminating phosphorus from the first stage washer. This technology is presently employed by a number of windshield fabrication plants.

Major changes in the production process are not anticipated. It should be noted, however, that minor process changes to adjust for automobile model changes are required yearly for automotive glass fabricating plants. These generally do not significantly affect waste water volumes or characteristics. This technology can be applied so that upsets and other fluctuations in process operations can be accommodated without exceeding the effluent limitations.

Non-Water Quality Environmental Impact

There is no evidence that application of this control technology will result in any unusual air pollution or solid waste disposal problems, either in kind or magnitude. The costs of avoiding problems in these areas are not excessive. The energy required to apply this control technology represents only a small increment of the present total energy requirements of the industry.

SECTION X

EFFLUENT REDUCTION ATTAINABLE THROUGH THE APPLICATION OF THE BEST AVAILABLE TECHNOLOGY ECONOMICALLY ACHIEVABLE EFFLUENT LIMITATIONS GUIDELINES

INTRODUCTION

The effluent limitations that must be achieved July 1, 1983, are to specify the degree of effluent reduction attainable through the application of the Best Available Technology Economically Achievable. This control technology is not based upon an average of the best performance within an industrial category, but is determined by identifying the very best control and treatment technology employed by a specific plant within the industrial category or subcategory, or where it is readily transferable from one industry process to another.

Consideration must also be given to:

a. The total cost of application of this control technology in relation to the effluent reduction benefits to be achieved from such application;

b. the size and age of equipment and facilities involved;

c. the processes employed;

d. the engineering aspects of the application of this control technology;

e. process changes; and

f. non-water quality environmental impact (including energy requirements).

Best Available Technology Economically Achievable also considers the availability of in-process controls as well as control or additional end-of-pipe treatment techniques. This control technology is the highest degree that has been achieved or has been demonstrated to be capable of being designed for plant scale operation up to and including "no discharge" of pollutants.

Although economic factors are considered in this development, the costs for this level of control are intended to be the top-of-the-line of current technology subject to limitations imposed by economic and engineering feasibility. However, this control technology may be characterized by some technical risk with respect to performance and with respect to certainty of costs. Therefore, this control technology may necessitate some industrially sponsored development work prior to its application.

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EFFLUENT REDUCTION ATTAINABLE THROUGH THE APPLICATION OF BEST AVAILABLE TECHNOLOGY ECONOMICALLY ACHIEVABLE

Based on the information contained in Sections III through VIII of this document, a determination has been made of the degree of effluent reduction attainable through the application of the Best Available Technology Economically Achievable. No discharge is attainable for the sheet and rolled glass subcategories as is indicated in Section IX. The effluent reductions attainable for the other subcategories are summarized here.

Suspended Solids

Suspended solids are reduced by more than 95% for the plate, and solid tempered automotive glass subcategories by this technology. The incremental increase over the levels achieved using the Best Practicable Control Technology Currently Available is 67% or greater. This technology effects a 67% suspended solids reduction in the float waste water and an 80% suspended solids reduction in windshield lamination waste water. The low percent reduction in these cases is a result of the relatively high quality of the raw waste water.

Oil

This technology reduces oil discharged from the windshield fabrication process by 98%, and from the solid tempered glass process by 62%, and also from the float process. The incremental increase for windshield fabrication over the application of the Best Practicable Pollution Control Technology Currently Available is 50%. The lower reduction achieved for the solid tempered process is due to the low oil concentration in the raw waste water. The best available technology economically achievable will further reduce oil discharged from the float process below detectable limits.

Oxygen Demanding Materials

The COD discharged by the plate process is reduced by 98% or more with this technology, but no reduction is achieved for windshield fabrication waste waters. The incremental increase in COD removal over the level achieved using the Best Practicable Control Technology Currently Available is 80% for the plate glass process.

This technology reduces the BOD in solid tempered automotive glass waste water by only 33% because the raw waste water is of high quality.

Total Phosphorus

With this technology, total phosphorus discharged by the windshield fabrication process is reduced 80%. Phosphorus is not a significant constituent in plate glass and solid tempered automotive glass waste waters.

Other Pollutant Constituents

Temperature and dissolved solids, which are discussed in Section IX, are not significantly reduced by this technology.

IDENTIFICATION OF BEST AVAILABLE CONTROL TECHNOLOGY ECONOMICALLY ACHIEVABLE

Both in-plant controls and end-of-pipe treatment technology constitutes the Best Available Pollution Control Technology Economically Achievable. This technology is summarized below and recommended daily average effluent limitations are listed in Table 15. The limitations are expressed in grams or kilograms of pollutant per metric ton or 1000 square meters of product.

Plate Glass Manufacturing

The control technology is improvement of existing lagoon systems as described in Section IX, return of 80% of the lagoon effluent to the grinding operation, sand filtration of the remaining 20%, and return of the filter backwash to the head of the lagoon system. Effluent limitations for suspended solids are 0.045 kg/metric ton (0.09 lb/short ton) and for COD are 0.09 kg/metric ton (0.18 lb/short ton).

Float Glass Manufacturing

The control technology is elimination of detergent usage from the float washing process as described in Section IX followed by oil absorptive diatomaceous earth filtration. Waste solids are disposed of to landfill. Effluent limitations for suspended solids are 0.70 g/kkg (0.0014 lb/ton); for oil are 1.40 g/kkg (0.0028 lb/ton), for phosphorous are 0.05 g/kkg (0.0001 lb/ton), and a pH between 6.0 and 9.0.

Solid Tempered Automotive Glass Fabrication

The control technology is coagulation-sedimentation of all process waste waters as described in Section IX followed by oil absorptive diatomaceous earth filtration. Waste solids are disposed of to landfill. Effluent limitations for suspended solids and oil are 0.24 g/sq m (0.05 lb/1000 sq ft) and for BOD are 0.49 g/sq m (0.1 lb/ 1000 sq ft).

Windshield Fabrication

The control technology is recycle of the post-lamination washer initial hot water rinse and gravity separation of the remaining post-lamination rinse waters as described in Section IX, oil absorptive diatomaceous earth filtration of the total process waste water discharge, and reduction of detergent usage. Effluent

TABLE 15

RECOMMENDED DAILY AVERAGE EFFLUENT LIMITATIONS USING BEST AVAILABLE CONTROL TECHNOLOGY ECONOMICALLY ACHIEVABLE

	Suspended Solids	Oil	Total Phosphorus	pH
Sheet Glass	No waste water discharge			
Rolled Glass	No waste water discharge			
Plate Glass				
kg/metric ton	0.045	-	-	6-9
lb/short	0.090			
Float Glass				
g/metric ton	0.70	1.40	0.05	6-9
lb/short ton	0.0014	0.0028	0.0001	
Solid Tempered Automotive Glass				
g/sq m	0.24	0.49	-	6-9
lb/1000 sq ft	0.05	0.10		
Windshields				
g/sq m	0.88	1.76	0.30	6-9
lb/1000 sq ft	0.18	0.36	0.06	

limitations for suspended solids and oil are 0.88 g/sq m (0.18 lb/ 1000 sq ft), for COD 4.9 g/sq m (1.0 lb/1000 sq ft), and for phosphorus are 0.2 g/sq m (0.04 lb/1000 sq ft).

RATIONALE FOR THE SELECTION OF BEST AVAILABLE TECHNOLOGY ECONOMICALLY ACHIEVABLE

Total Cost of Application

Based upon the information contained in Section VIII of this document, the industry as a whole would have to invest up to an estimated maximum of $3,200,000 to achieve the effluent limitations prescribed herein. The increased annual costs to the industry would be approximately $1,000,000.

Size and Age of Equipment and Facilities

As discussed in Section IX, differences in size and age of equipment and facilities in the industry do not play a significant role in the application of this control technology.

Processes Employed

The manufacturing processes employed within each subcategory of the industry are basically similar and the differences will not influence the applicability of this control technology.

Engineering Aspects of Application

This level of technology is not achieved by any plants in the industry at the present time. However, as indicated in Section VII of this document, there is a high degree of confidence that this technology can be implemented in the industry by 1983. The treatment and systems are now used in other industries and this technology can be readily transferred to the flat glass industry. The derivation and rational for selection of the control technology are described in detail in Section VII. These may be briefly summarized as follows:

Plate Glass Manufacturing

Rapid sand filtration is a thoroughly proven technology that is used extensively in the water treatment industry. Effluent concentrations below the proposed effluent limits are commonly achieved. The lagoon effluent should be suitable for recycle because the suspended solids level is in most cases lower than the concentration of the raw river water presently being used.

Float Glass Manufacturing

Process waste water pollutants in float glass washwater can be further reduced by diatomaceous earth filtration. The limitations allow a discharge after filtration but some plants may be able to recycle this water as batch or cooling water make-up. With the exception of temperature, the waste water characteristics are not significantly different from the city water presently being used for this purpose.

Solid Tempered Autmotive Glass and Windshield Fabrication

Oil absorbtive diatomaceous earth filtration is the additional treatment technology recommended for both the solid tempered automotive and windshield fabrication subcategories. This technology is commonly used to remove oil and suspended solids from boiler water condensate and effluent concentrations of less than 5 mg/l are readily achievable for both parameters. There is no evidence to indicate that this technology can not be applied to waste water treatment in the glass industry.

Process Changes

Only one process change is effected by this control technology. Reduction of detergent usage in the windshield fabrication process is required. Although the exemplary plant upon which this technology is based required no equipment modification to achieve the technology, it is possible, but not anticipated, that equipment modification may be required in other plants. Recycling of water is not required by the technology, but it is likely plants will reduce water usage to a minimum to reduce treatment costs.

Non-Water Quality Environmental Aspects

The application of this control technology will not create any new air or land pollution problems, but will require approximately 2.5 times more energy than is required for the application of the Best Practicable Control Technology Currently Available. This is still estimated to be less than 10% of the energy required for the manufacturing process.

SECTION XI

NEW SOURCE PERFORMANCE STANDARDS

The term "new source" is defined to mean "any source, the construction of which is commenced after the publication of the proposed regulations prescribing a standard of performance." New sources from the sheet, rolled, float, and solid tempered automotive glass and windshield subcategories should achieve the effluent limitations prescribed as attainable through the application of the Best Available Technology Economically Achievable. This technology reduces the concentration of pollutant constituents to low levels and no other technology is indicated that will further reduce these levels by virtue of new construction.

New sources in the plate glass subcategory should achieve no discharge of process waste waters to navigable waters. This regulation will most probably prevent the construction of any new plate glass plants. This type of glass can be produced more economically and with almost no water pollution by the float process with the technologies recommended in this document. Owing to the high operating costs associated with plate glass production, new source construction would be very unlikely even without effluent limitations.

SECTION XII

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SECTION XIII

REFERENCES

1. Betz Handbook of Industrial Water Conditioning, Betz Laboratories, Philadelphia, Pa., 1962.

2. Dietz, A. G. H., Engineering Laminates, John Wiley & Sons, New York, 1949.

3. Handbook of Chemistry and Physics - 38th Edition, Chemical Rubber Publishing Co., P. 503 & 533, 1956.

4. Hardenbergh, W. A. and Rodie, E. B., Water Supply and Waste Disposal, International Textbook, Scranton, Pa., 1963.

5. Industrial Waste Study Report: Flat Glass, Cement, Lime, Gypsum, and Asbestos Industries, report to Environmental Protection Agency by Sverdrup & Parcel and Associates, Inc., 1971.

6. Johns-Manville Technical Data Sheet No. FF-214, New York

7. Lynam, B., Ettelt, G., and McAloon, T., "Tertiary Treatment at Metro Chicago by Means of Rapid Sand Filtration and Microstrainers", Journal Water Pollution Control Federation, 41, No. 2, P. 247, 1969.

8. Methods for Chemical Analysis of Water and Wastes, Environmental Protection Agency, National Environmental Research Center, Analytical Quality Control Laboratory, Cincinnati, Ohio, 1971.

9. Patterson, W. L. and Banker, R. F., Estimating Costs and Manpower Requirements for Conventional Waste water Treatment Facilities, Black and Veatch, Consulting Engineers for the Office of Research and Monitoring, Environmental Protection Agency, 1971.

10. Persson, R., Flat Glass Technology, Butterworths, London, 1969.

11. Porter, J. W., Hopkins, A. N., Fisher, W. L., "An Economic and Engineering Analysis of Municipal Waste water Renovation", Water, 90, No. 64, P. 246, 1968.

12. Probstein, R. F., "Desalinization", American Scientist, Society of Sigma Xi, New Haven, Conn., May - June, 1973.

13. Sewage Treatment Plant and Sewer Construction Cost Indexes, Environmental Protection Agency, Office of Water Programs Operations, Municipal Waste water Systems Division, Evaluation and Resource Control Branch.

Preceding page blank

14. Shand, E. B., *Glass Engineering Handbook*, McGraw-Hill, New York, 1958.

15. Smith, Robert, *Cost of Conventional and Advanced Treatment of Waste water*, Federal Water Pollution Control Administration, U.S. Department of the Interior, 1968.

16. Smith, Robert and McMichael, Walter F., *Cost and Performance Estimates for Tertiary Waste water Treating Processes*, Federal Water Pollution Control Administration, U.S. Department of the Interior, 1969.

17. *Standard Industrial Classification Manual*, Office of Management and Budget, U.S. Government Printing Office, Washington, D.C., P. 136 - 138, 1972.

18. *Standard Methods for the Examination of Water and Waste water*, 13th Edition, American Public Health Association, Washington, D.C., 1971.

19. *Water Treatment Plant Design*, American Water Works Association, New York, 1969.

SECTION XIV

GLOSSARY

Act

The Federal Water Pollution Control Act Amendments of 1972.

Annealing

Prevention or removal of objectionable stresses by controlled cooling from a suitable temperature.

Batch

The raw materials, properly proportioned and mixed, for delivery to the furnace.

Blowdown

A discharge from a system, designed to prevent a buildup of some material, as in a boiler to control dissolved solids.

Category and Subcategory

Divisions of a particular industry which pose different traits which affect water quality and treatability.

Cooling Water

Water used primarily for dissipation of process heat. Can be both contact or non-contact, and is usually the latter.

Cullet

Broken glass generated in the manufacturing or fabricating processes.

Diatomaceous Earth

The skeletal remains of tiny aquatic plants, commonly used as a filter medium to remove suspended solids from fluids. Specially treated diatomaceous earth can be obtained for the removal of emulsified oil from water.

Fabrication

Used in this report in conjunction with processes which use flat glass as the raw material, such as windshield laminating.

Felt

Material, animal in origin, used in polishing pads for applying the polishing medium (iron oxide or cerium oxide slurry) in polishing plate glass.

Laminating

A process of constructing in layers to produce a product with composite properties which are different from those of the components, as in automotive windshields which are made shatter-resistant by laminating.

Lap

A large iron grinding wheel used in conjunction with a graded sand slurry for grinding plate glass.

Lehr

A long tunnel-shaped oven for annealing glass by continuous passage.

Manufacturing

Used in this report in conjunction with the primary float, plate, sheet and rolled processes.

New Source

Any building, structure, facility, or installation from which there is or may be a discharge of pollutants and whose construction is commenced after the publication of the proposed regulations.

Process Water

Any water which comes into direct contact with the intermediate or final product. Includes contact cooling, washing, grinding and polishing, etc.

Seaming

A light grinding or sanding process for removal of the sharp edges produced by cutting of the glass, primarily for safety in handling.

Supernatant

The layer floating above the surface of a layer of solids, as the liquid phase in a solids-separating centrifuge.

Surface Waters

Navigable waters. The waters of the United States including the territorial seas.

Tempered Glass

Glass that has been rapidly cooled from near the softening point, under rigorous control, to increase its mechanical and thermal endurance.

Washer

A process device used for water cleaning of the product.

Waste Water

Process water or contact cooling water which has become contaminated with process waste and may no longer be usable.

CONVERSION TABLE

MULTIPLY (ENGLISH UNITS) by TO OBTAIN (METRIC UNITS)

ENGLISH UNIT	CONVERSION	METRIC UNIT
acre	0.405	hectares
acre - feet	1233.5	cubic meters
British Thermal Unit	0.252	kilogram - calories
BTU/short ton	0.278	kilogram - calories/ metric ton
BTU/square foot	2.71	kilogram - calories/ square meter
feet	0.3048	meters
gallons	3.785	liters
gallons/minute	0.0631	liters/second
gallons/1000 square feet	0.0407	liters/square meter
gallons/short ton	4.17	liters/metric ton
horsepower	0.74557	kilowatts
inches	2.54	centimeters
pounds	0.454	kilograms
pounds/1000 square feet	0.00489	kilograms/square meter
pounds/short ton	0.5	kilograms/metric ton
million gallons/day	33785.0	cubic meters/day
square feet	0.0929	square meters
tons (short)	0.907	metric tons (1000 kilograms or kkg)

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